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Sano et al.

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(54) **STORAGE BATTERY SYSTEM AND SOLAR POWER GENERATION SYSTEM HAVING THE SAME**

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(51) **Int. Cl.**

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H02S 40/38	(2014.01)
H02S 40/30	(2014.01)
H02J 3/32	(2006.01)
H02J 3/38	(2006.01)

(52) **U.S. Cl.**

CPC ***H02J 7/35*** (2013.01); ***H02J 3/32*** (2013.01); ***H02J 3/383*** (2013.01); ***H02S 40/30*** (2014.12); ***H02S 40/38*** (2014.12); *Y02E 10/563* (2013.01); *Y02E 10/566* (2013.01); *Y02E 70/30* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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(57) **ABSTRACT**

A solar power generation system includes a storage battery, a solar power generation device that is provided on the side of the storage battery and outputs solar generated power, and a power control device. The power control device includes a variation component extraction unit that extracts a shade variation component from a generated power signal measured by the solar power generation device, a smoothing unit that smoothens the shade variation component obtained by the variation component extraction unit, a system output correction unit that obtains a system output power target value which is a combined output between a discharge output of the storage battery and the solar generated power on the basis of an output signal from the smoothing unit, and a charge/discharge output correction unit that corrects a charge/discharge target value which is a difference between the system output power target value and the generated power signal on the basis of a current time and a state of charge of the storage battery.

15 Claims, 17 Drawing Sheets

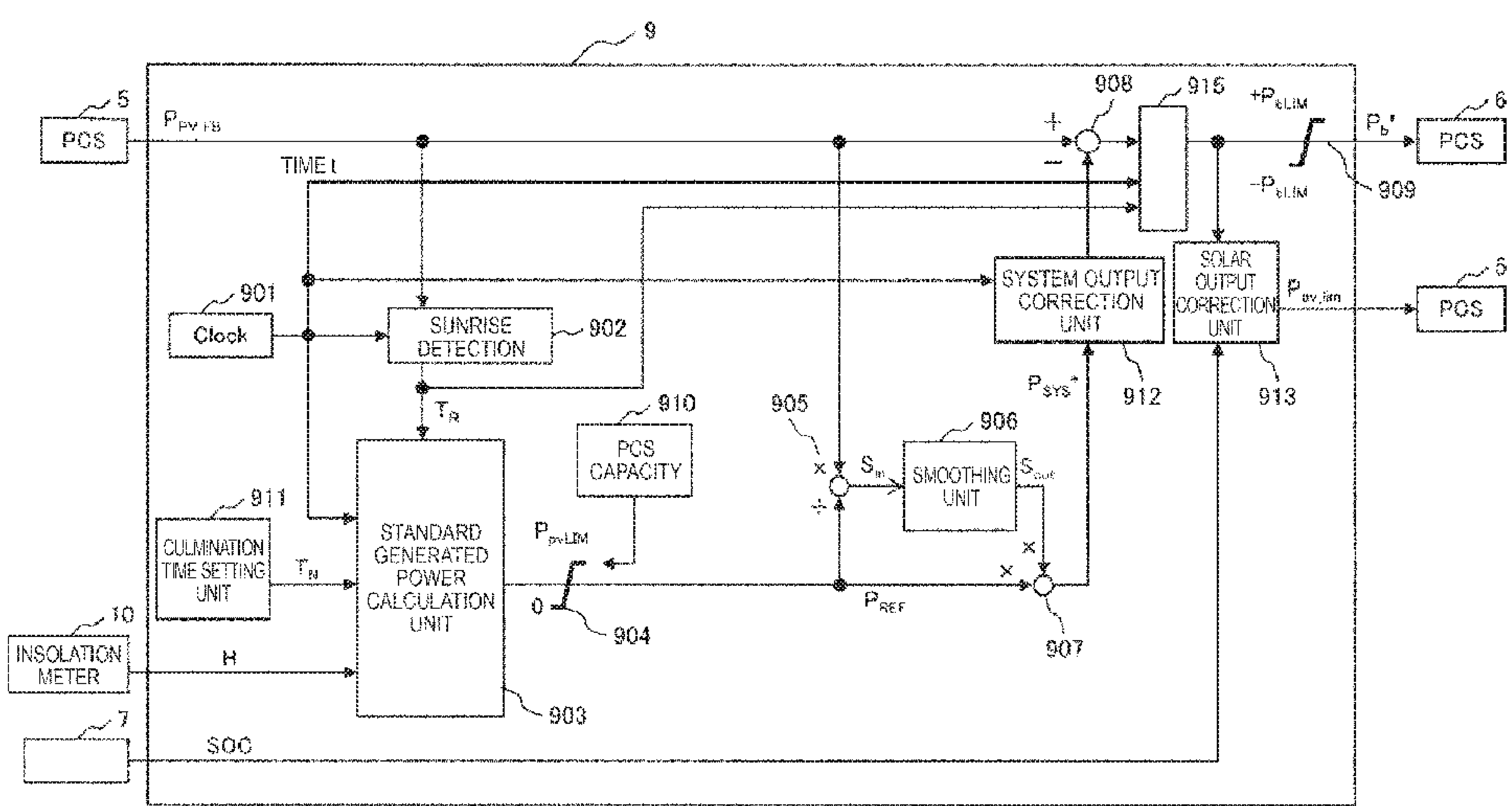


Fig. 1

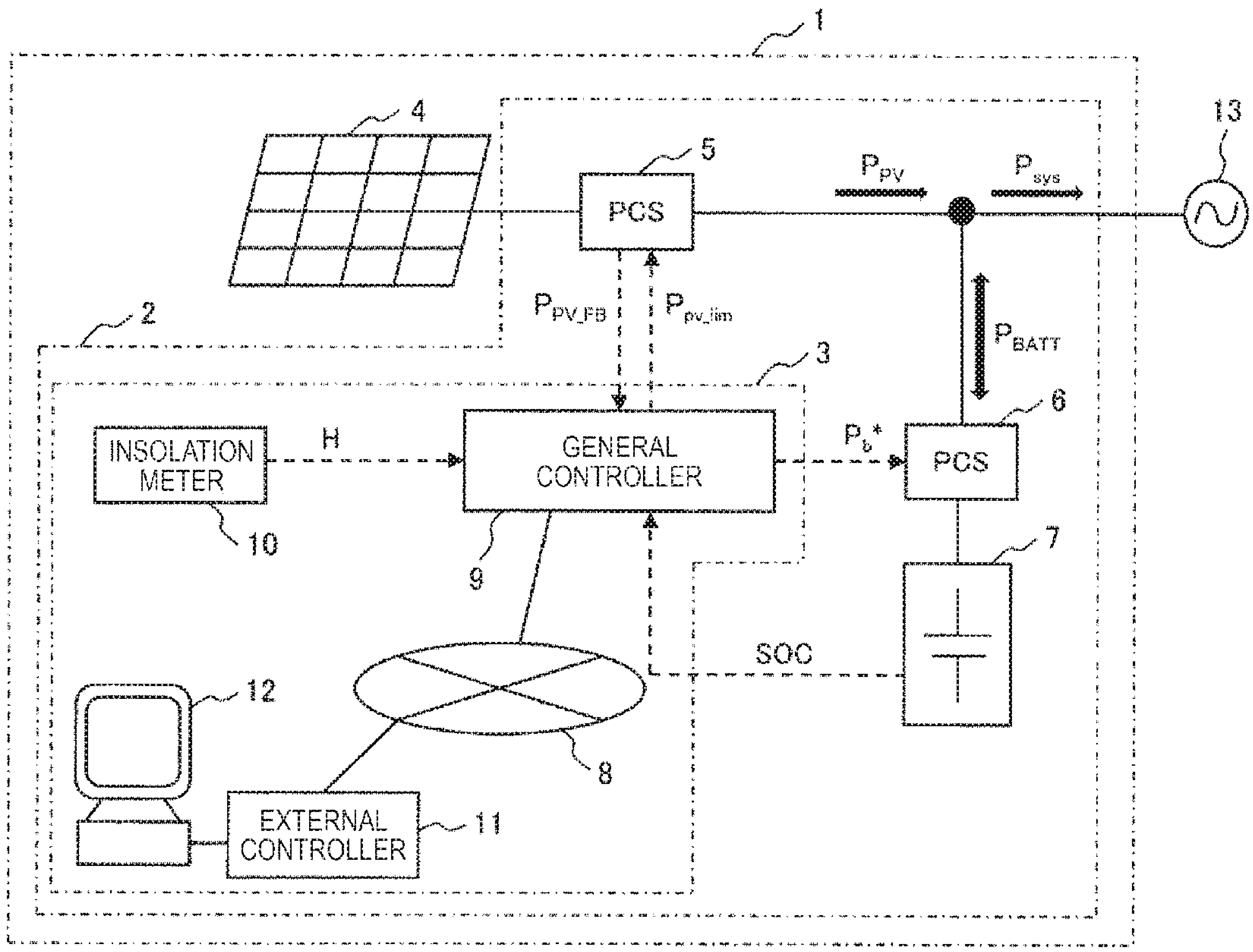

1
4
5
PCS
13
P_{PV}
P_{sys}
P_{PV_FB}
P_{pv_lim}
P_{BATT}
2
3
6
INSOLATION METER
H
GENERAL CONTROLLER
P_b^*
PCS
10
9
7
SOC
12
8
EXTERNAL CONTROLLER
11

Fig. 2

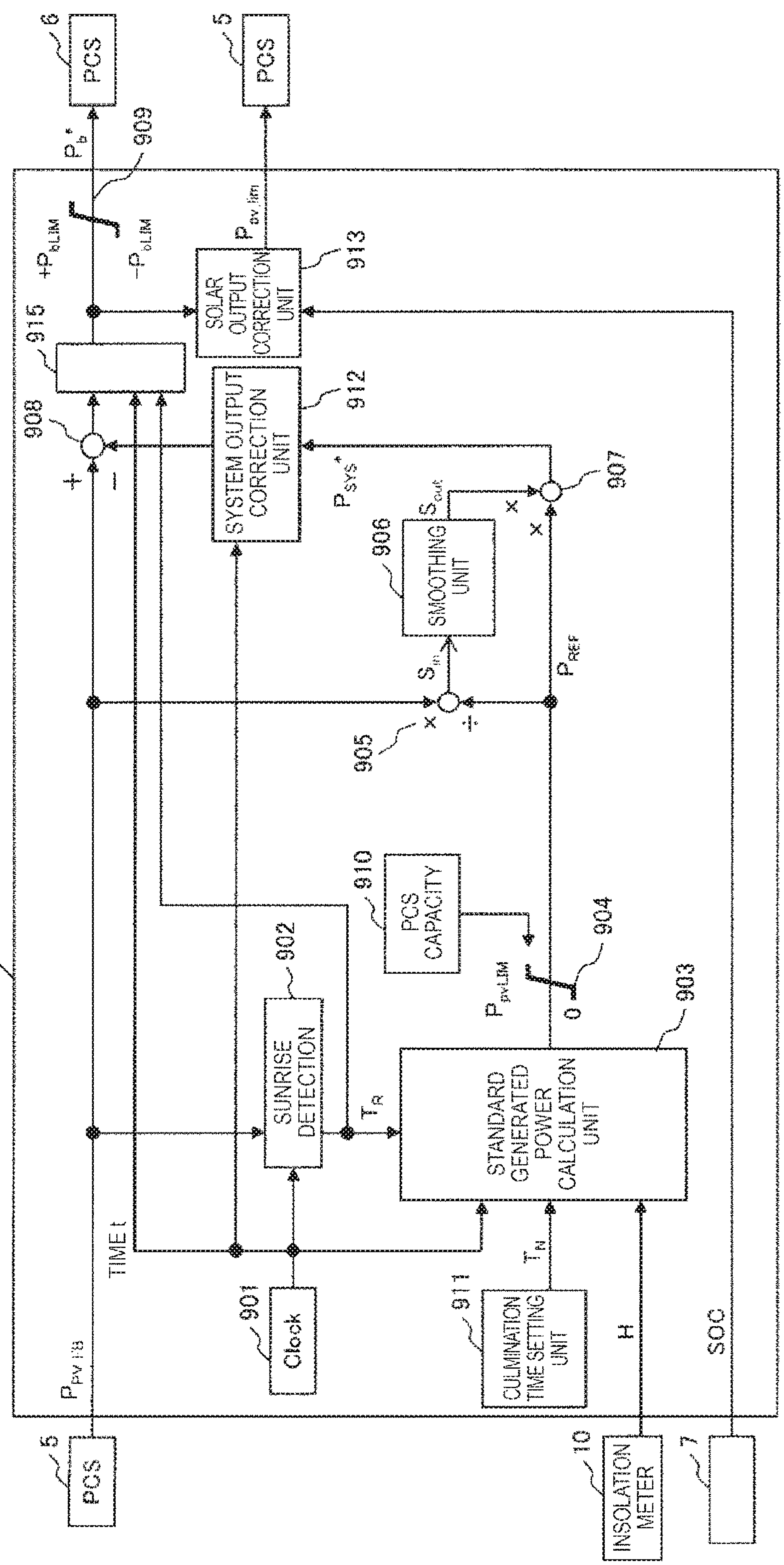

9
PCS
6
PCS
5
909
913
SOLAR OUTPUT CORRECTION UNIT
915
908
912
SYSTEM OUTPUT CORRECTION UNIT
907
906
SMOOTHING UNIT
905
910
PCS CAPACITY
904
902
SUNRISE DETECTION
903
STANDARD GENERATED POWER CALCULATION UNIT
901
Clock
911
CULMINATION TIME SETTING UNIT
TIME t
H
SOC
PCS
5
10
INSOLATION METER
7

Fig. 3

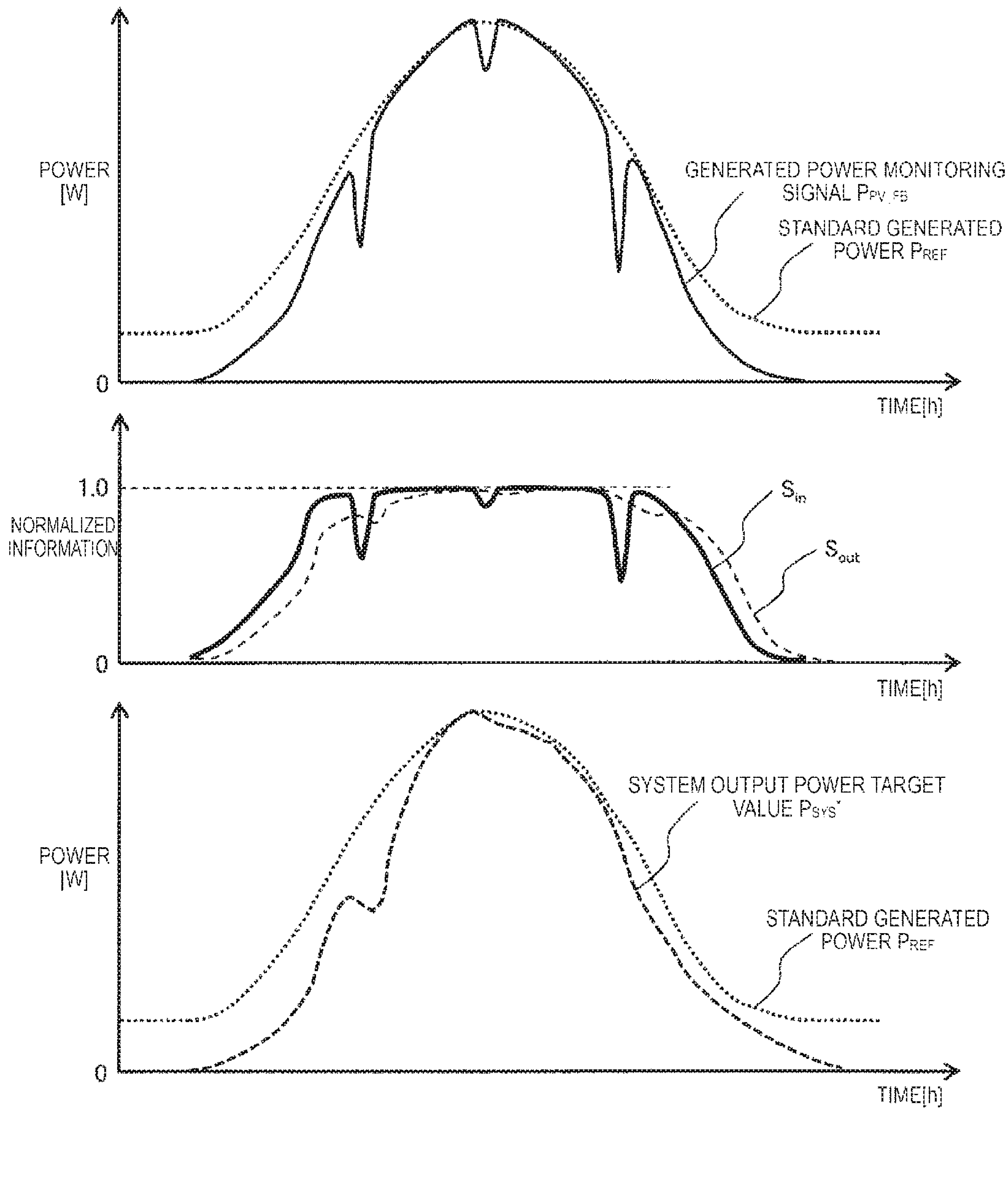
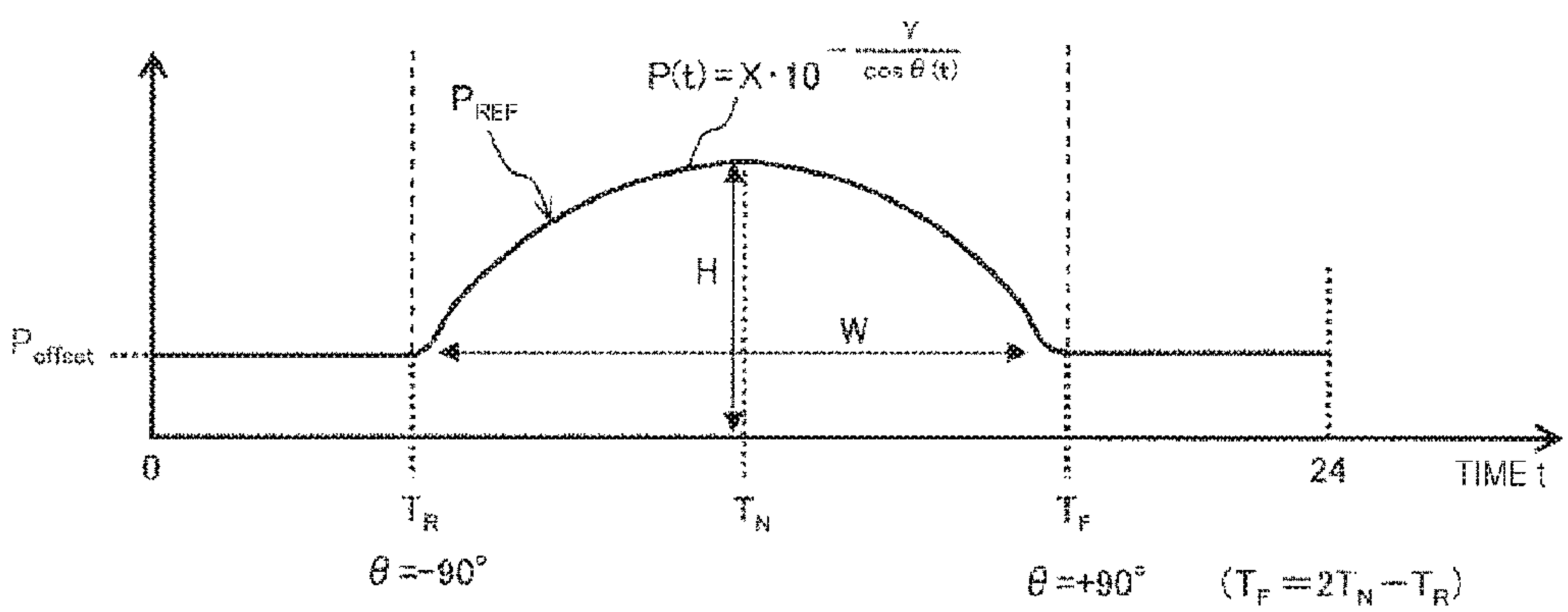
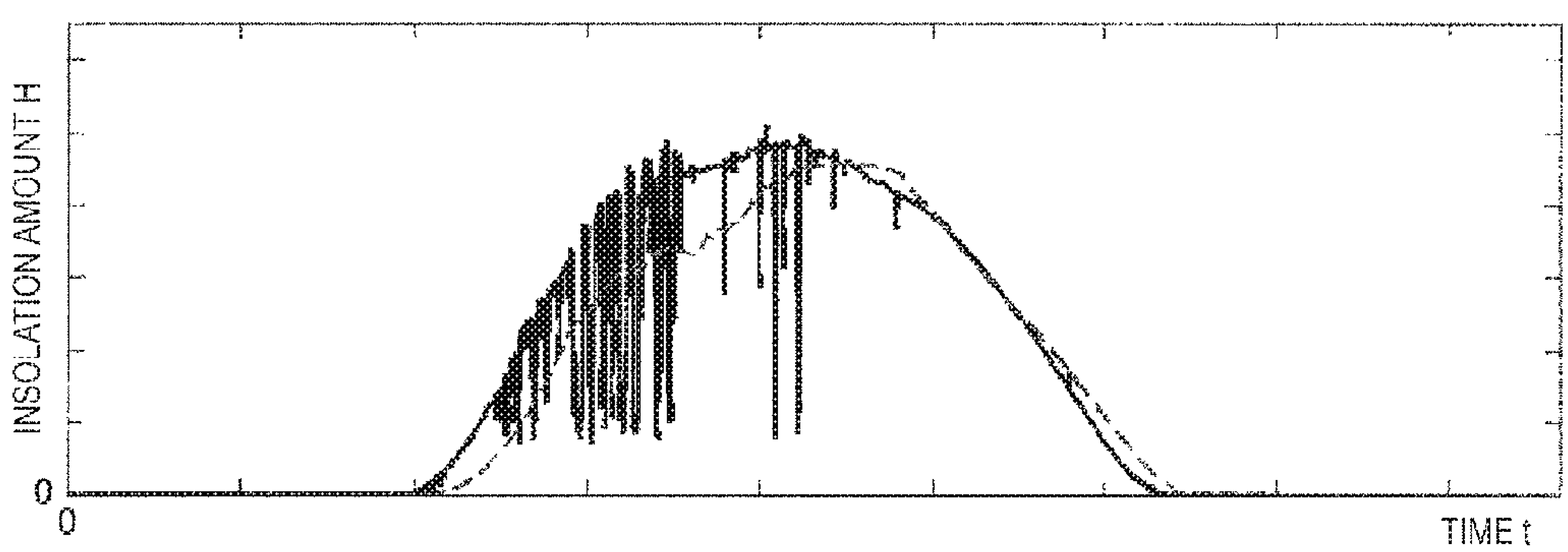

POWER
[W]
GENERATED POWER MONITORING
SIGNAL PPV_FB
STANDARD GENERATED
POWER PREF
0
TIME[h]
1.0
NORMALIZED
INFORMATION
Sin
Sout
0
TIME[h]
SYSTEM OUTPUT POWER TARGET
VALUE PSYS*
POWER
[W]
STANDARD GENERATED
POWER PREF
0
TIME[h]

Fig. 4



P(t)=X·10^(−Y/cos θ(t))
P_REF
H
W
P_offset
0
T_R
T_N
T_F
24
TIME t
θ=−90°
θ=+90°
(T_F=2T_N−T_R)

Fig. 5



INSOLATION AMOUNT H
0
0
TIME t

Fig. 6

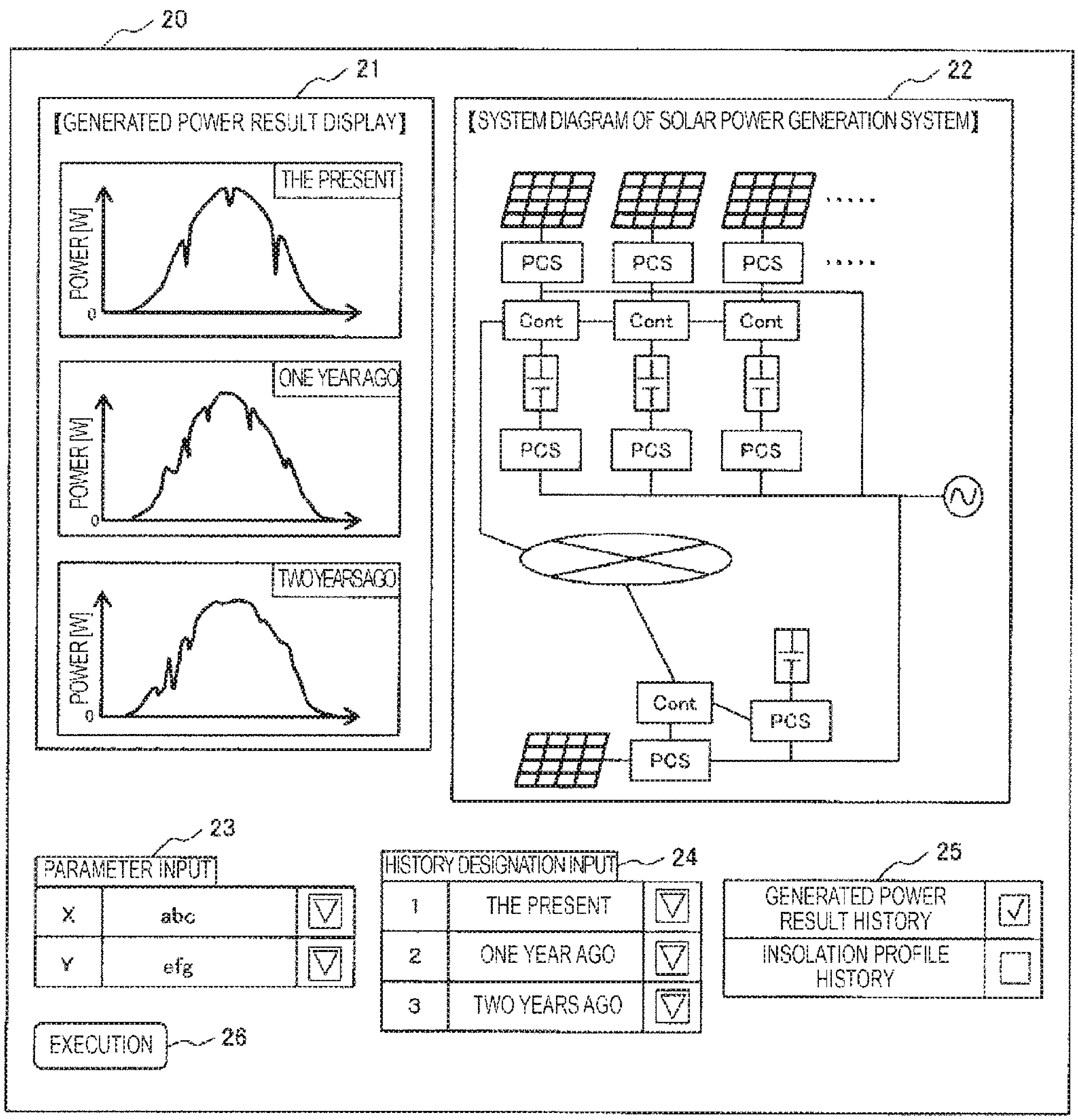

20
21
【GENERATED POWER RESULT DISPLAY】
THE PRESENT
ONE YEAR AGO
TWO YEARS AGO
POWER [W]
0
22
【SYSTEM DIAGRAM OF SOLAR POWER GENERATION SYSTEM】
PCS
Cont
23
PARAMETER INPUT
X abc
Y efg
24
HISTORY DESIGNATION INPUT
1 THE PRESENT
2 ONE YEAR AGO
3 TWO YEARS AGO
25
GENERATED POWER RESULT HISTORY
INSOLATION PROFILE HISTORY
EXECUTION
26

Fig. 7

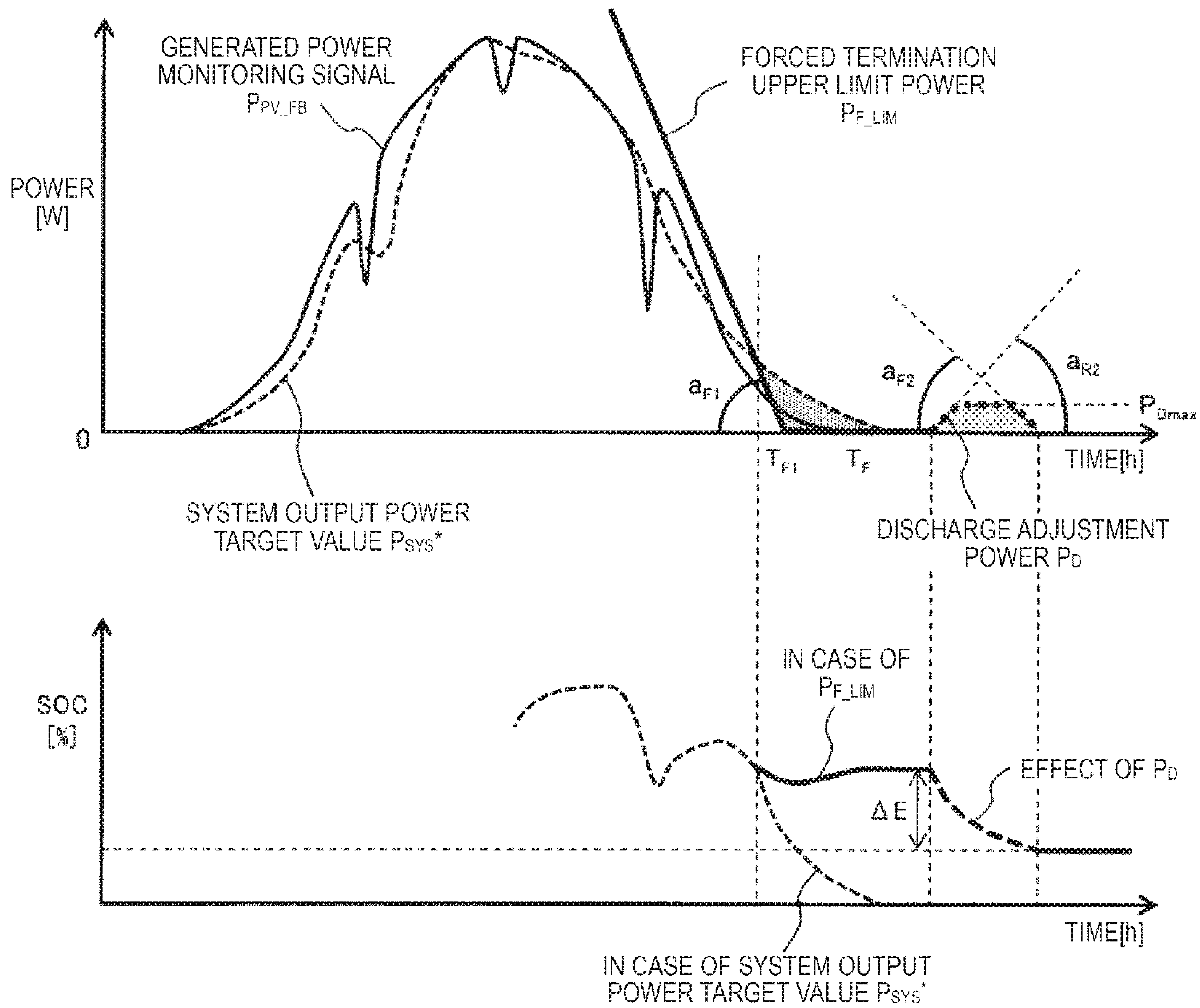
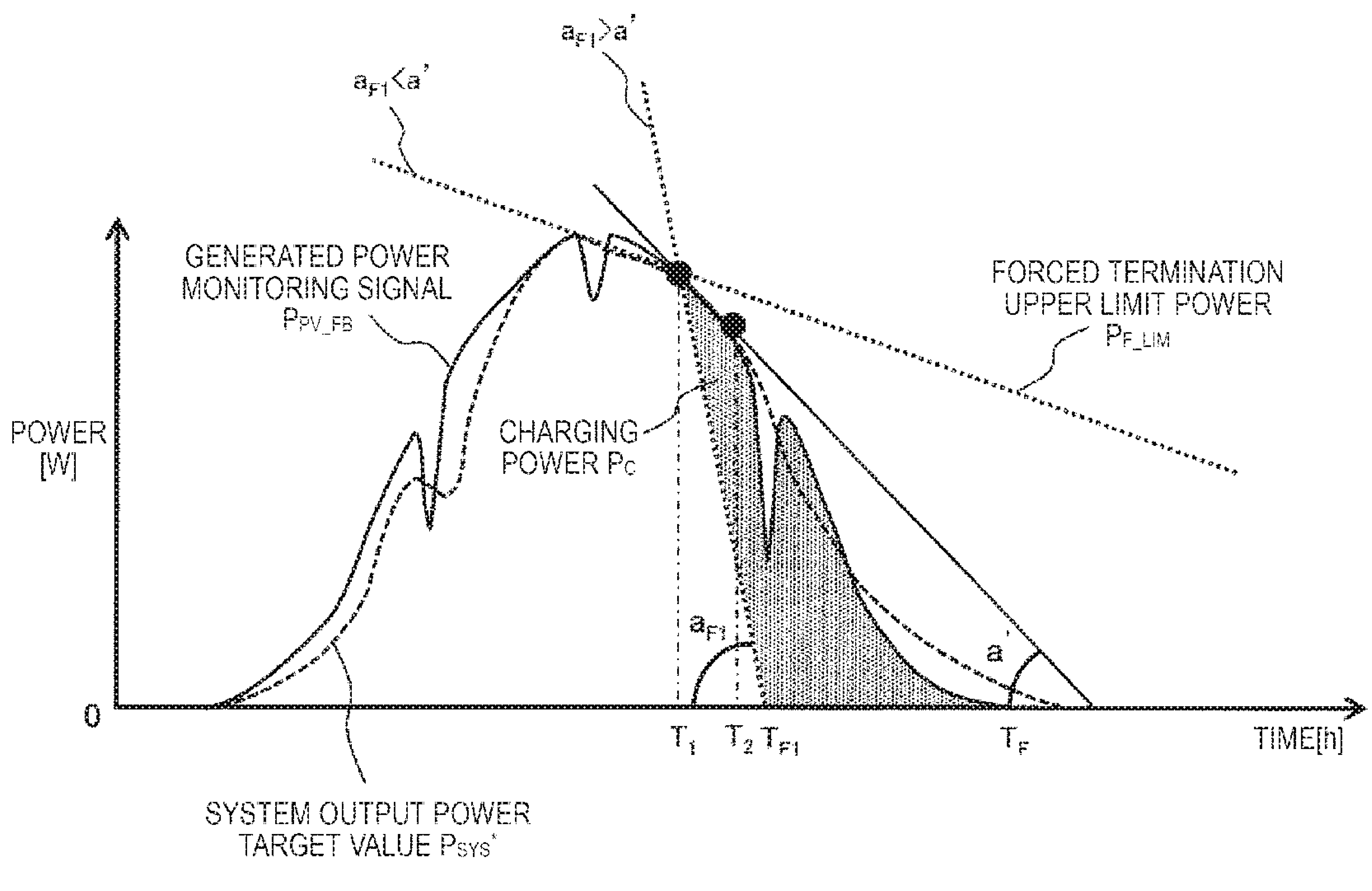

GENERATED POWER
MONITORING SIGNAL
P_{PV_FB}
FORCED TERMINATION
UPPER LIMIT POWER
P_{F_LIM}
POWER
[W]
0
a_{F1}
a_{F2}
a_{R2}
P_{Dmax}
T_{F1}
T_F
TIME[h]
SYSTEM OUTPUT POWER
TARGET VALUE P_{SYS}*
DISCHARGE ADJUSTMENT
POWER P_D
SOC
[%]
IN CASE OF
P_{F_LIM}
EFFECT OF P_D
ΔE
TIME[h]
IN CASE OF SYSTEM OUTPUT
POWER TARGET VALUE P_{SYS}*

Fig. 8



a_F1>a'
a_F1<a'
GENERATED POWER
MONITORING SIGNAL
P_PV_FB
FORCED TERMINATION
UPPER LIMIT POWER
P_F_LIM
POWER
[W]
CHARGING
POWER Pc
a_F1
a'
0
T1
T2
T_F1
T_F
TIME[h]
SYSTEM OUTPUT POWER
TARGET VALUE P_SYS'

Fig. 9

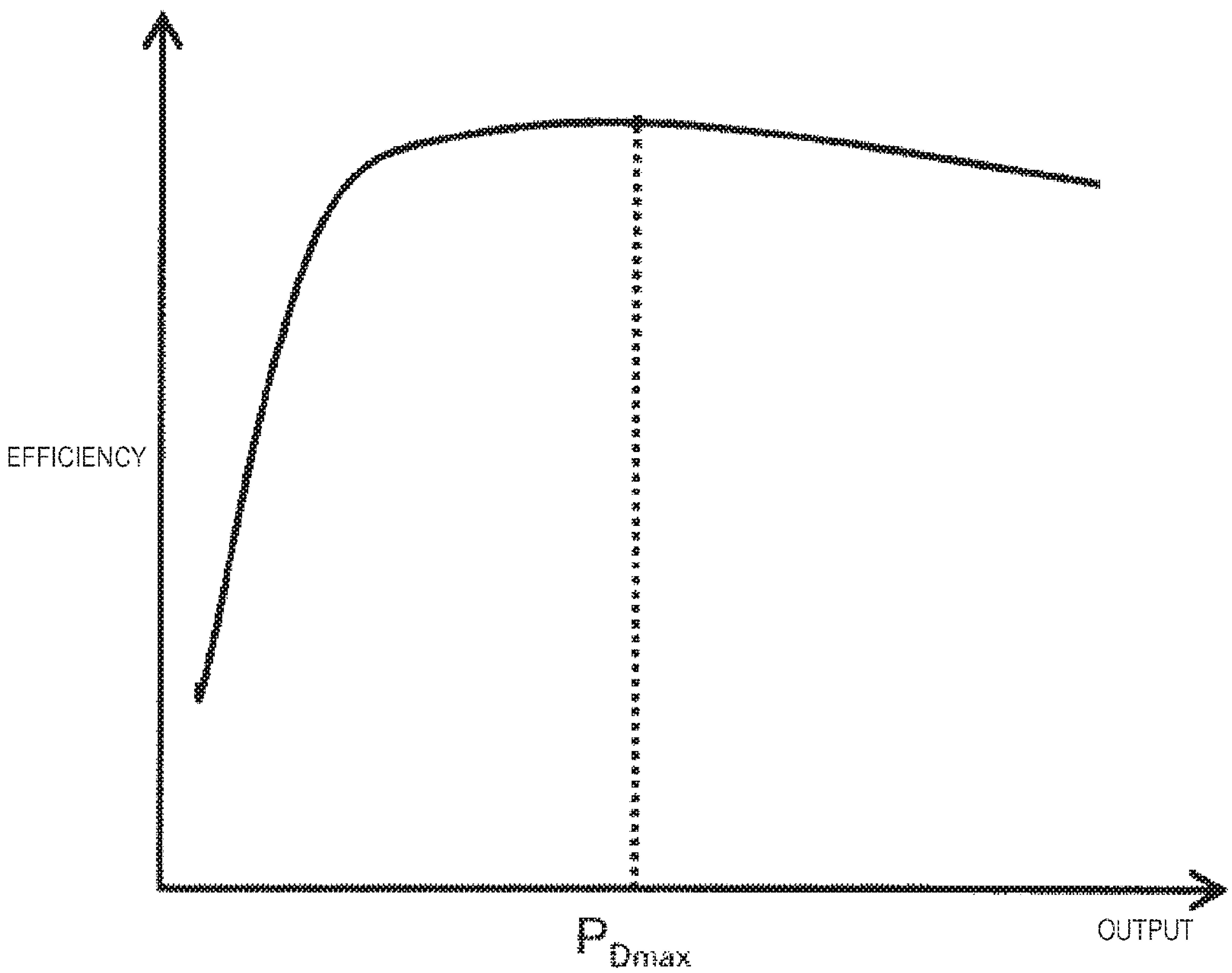


Fig. 10

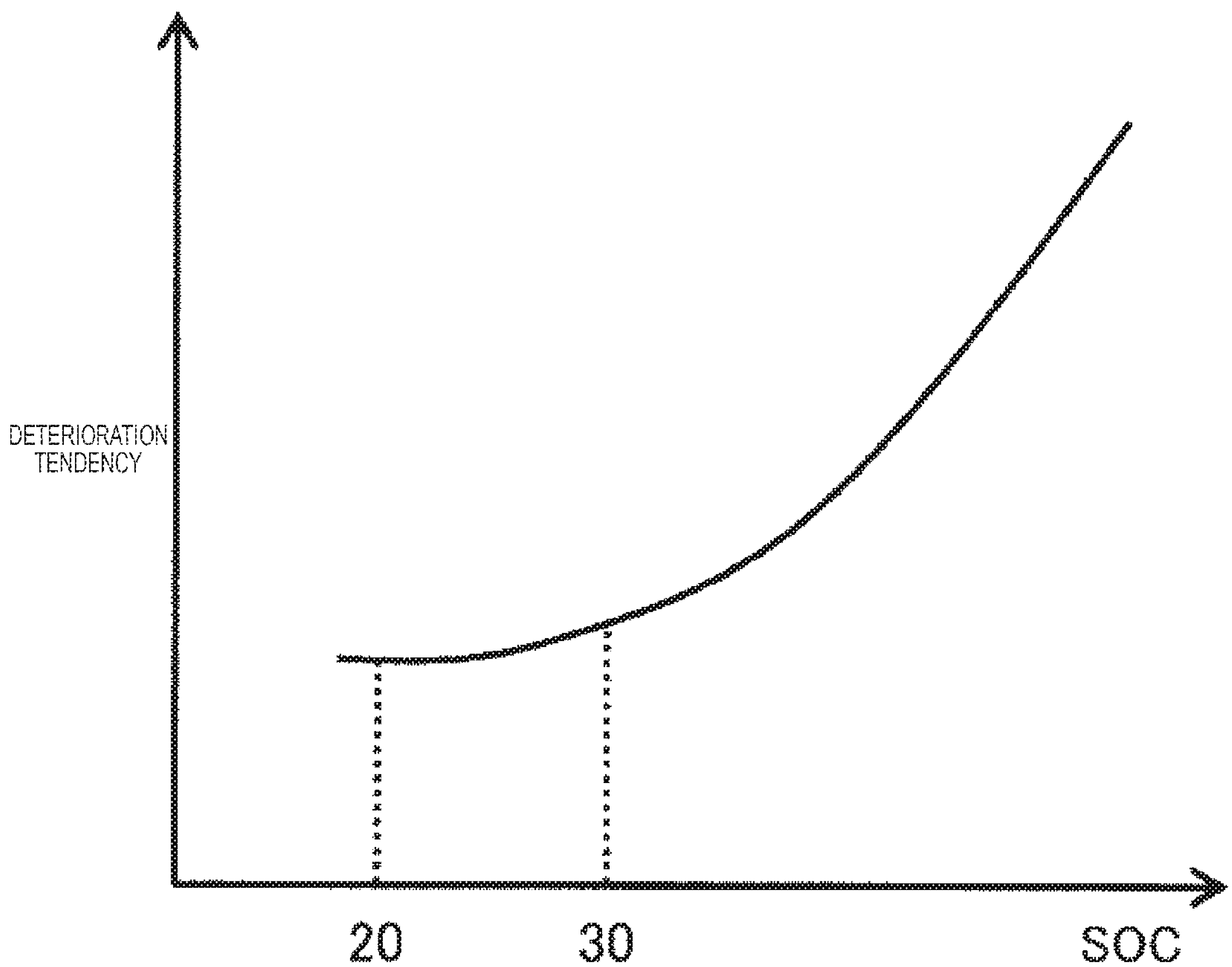


Fig. 11

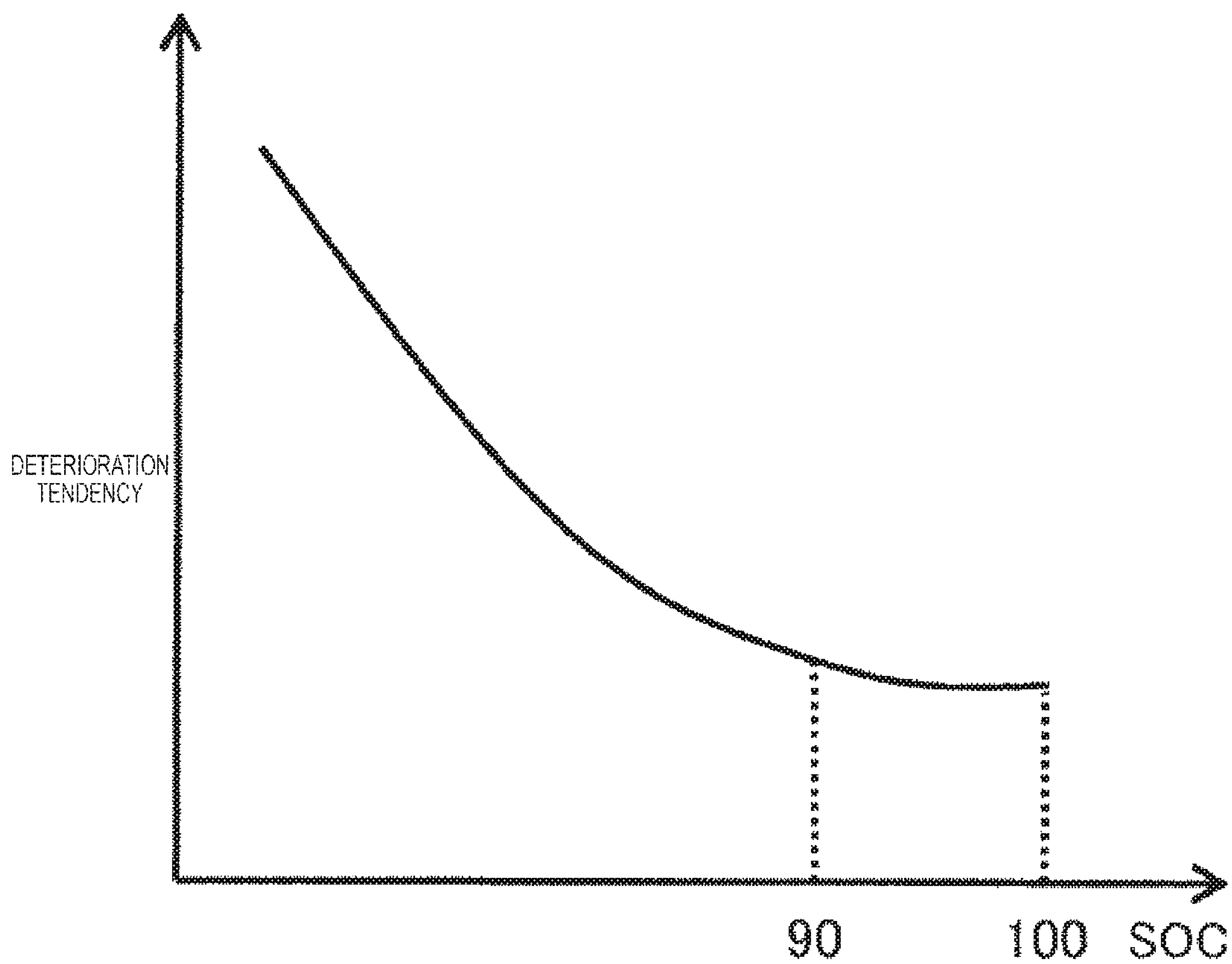


Fig. 12

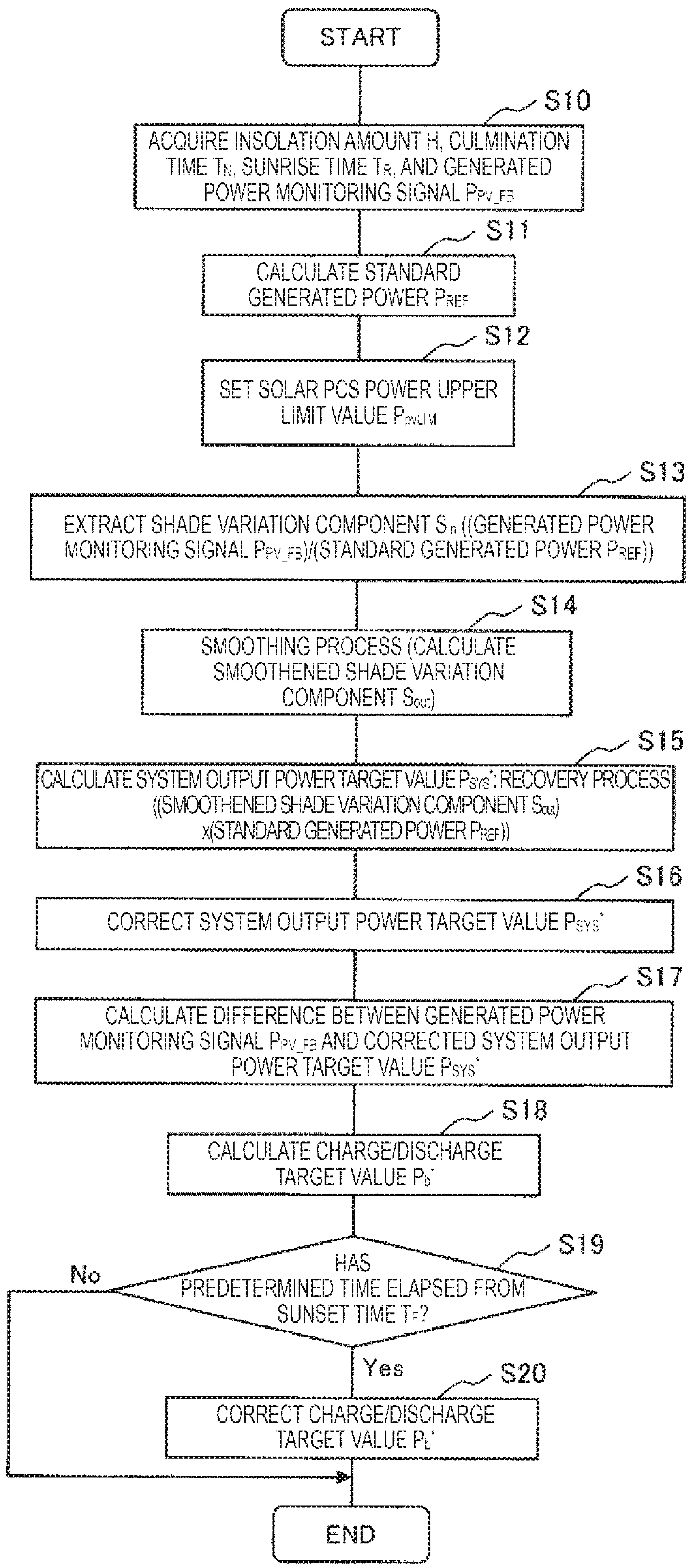

START
S10
ACQUIRE INSOLATION AMOUNT H, CULMINATION TIME T_N, SUNRISE TIME T_R, AND GENERATED POWER MONITORING SIGNAL P_{PV_FB}
S11
CALCULATE STANDARD GENERATED POWER P_{REF}
S12
SET SOLAR PCS POWER UPPER LIMIT VALUE P_{pvLIM}
S13
EXTRACT SHADE VARIATION COMPONENT S_n ((GENERATED POWER MONITORING SIGNAL P_{PV_FB})/(STANDARD GENERATED POWER P_{REF}))
S14
SMOOTHING PROCESS (CALCULATE SMOOTHENED SHADE VARIATION COMPONENT S_{out})
S15
CALCULATE SYSTEM OUTPUT POWER TARGET VALUE P_{SYS}^*: RECOVERY PROCESS ((SMOOTHENED SHADE VARIATION COMPONENT S_{out}) x(STANDARD GENERATED POWER P_{REF}))
S16
CORRECT SYSTEM OUTPUT POWER TARGET VALUE P_{SYS}^*
S17
CALCULATE DIFFERENCE BETWEEN GENERATED POWER MONITORING SIGNAL P_{PV_FB} AND CORRECTED SYSTEM OUTPUT POWER TARGET VALUE P_{SYS}^*
S18
CALCULATE CHARGE/DISCHARGE TARGET VALUE P_b^*
S19
HAS PREDETERMINED TIME ELAPSED FROM SUNSET TIME T_F?
No
Yes
S20
CORRECT CHARGE/DISCHARGE TARGET VALUE P_b^*
END

Fig. 13

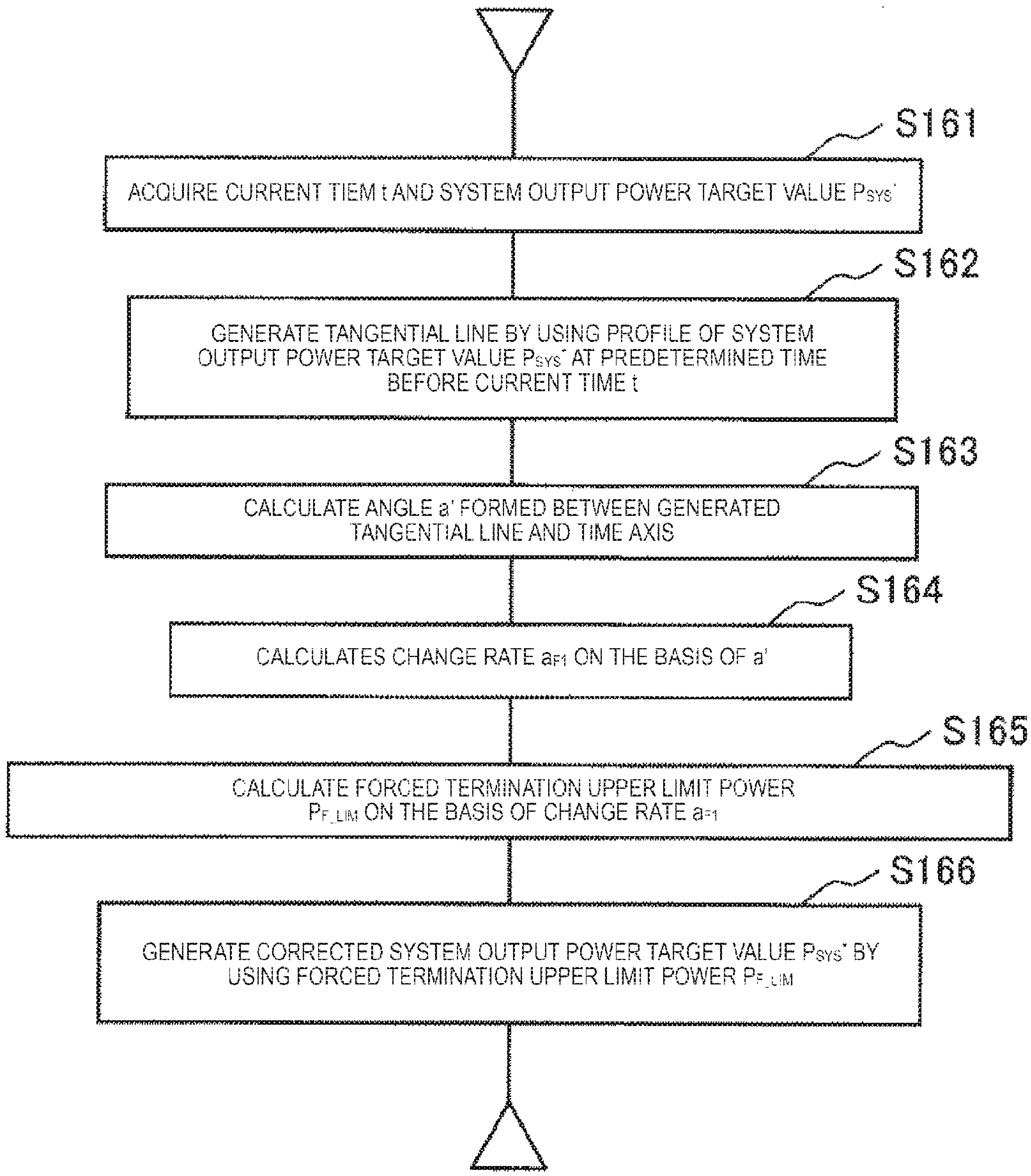

S161
ACQUIRE CURRENT TIEM t AND SYSTEM OUTPUT POWER TARGET VALUE PSYS'
S162
GENERATE TANGENTIAL LINE BY USING PROFILE OF SYSTEM OUTPUT POWER TARGET VALUE PSYS' AT PREDETERMINED TIME BEFORE CURRENT TIME t
S163
CALCULATE ANGLE a' FORMED BETWEEN GENERATED TANGENTIAL LINE AND TIME AXIS
S164
CALCULATES CHANGE RATE aF1 ON THE BASIS OF a'
S165
CALCULATE FORCED TERMINATION UPPER LIMIT POWER PF_LIM ON THE BASIS OF CHANGE RATE aF1
S166
GENERATE CORRECTED SYSTEM OUTPUT POWER TARGET VALUE PSYS' BY USING FORCED TERMINATION UPPER LIMIT POWER PF_LIM

Fig. 14

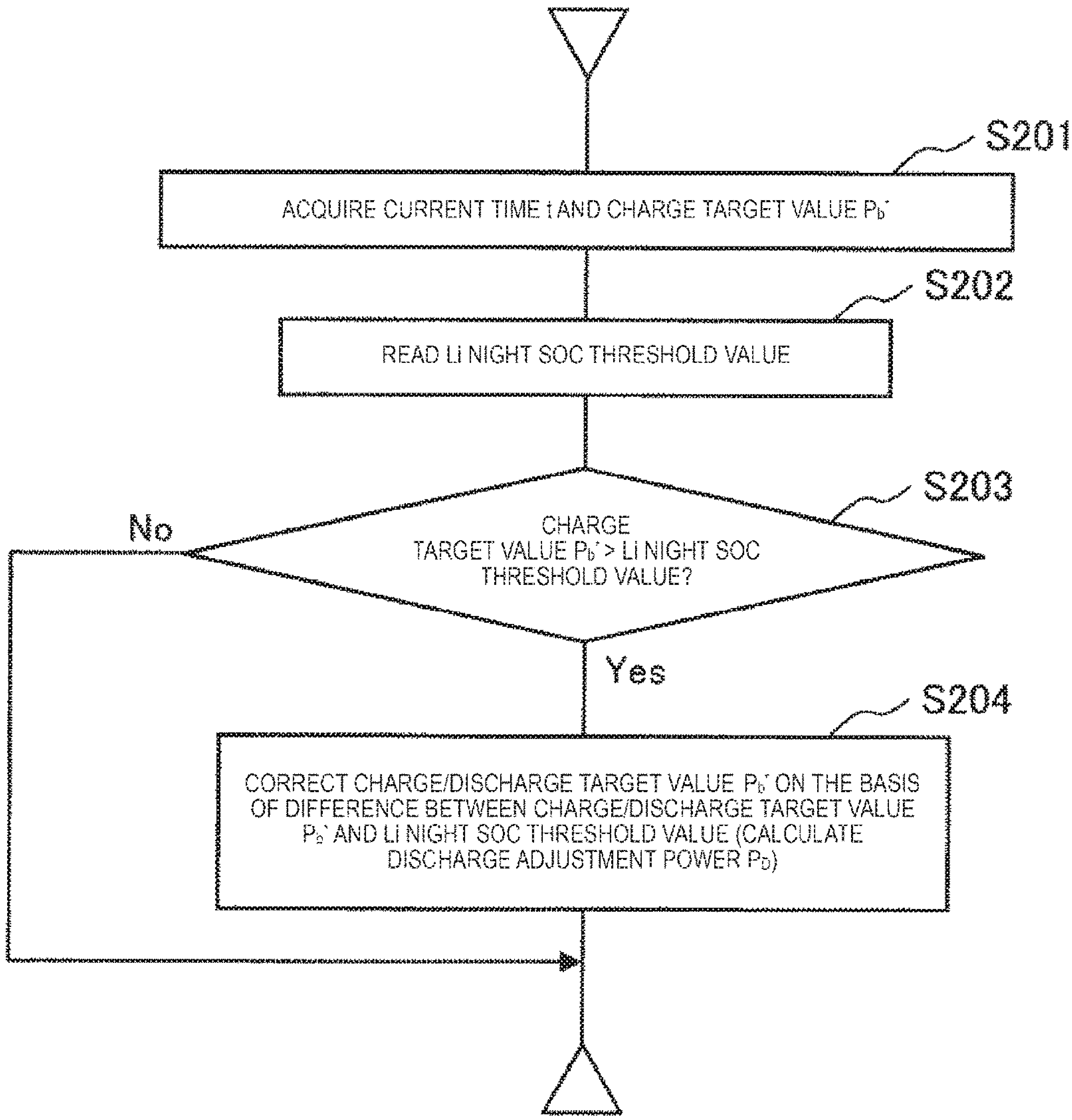
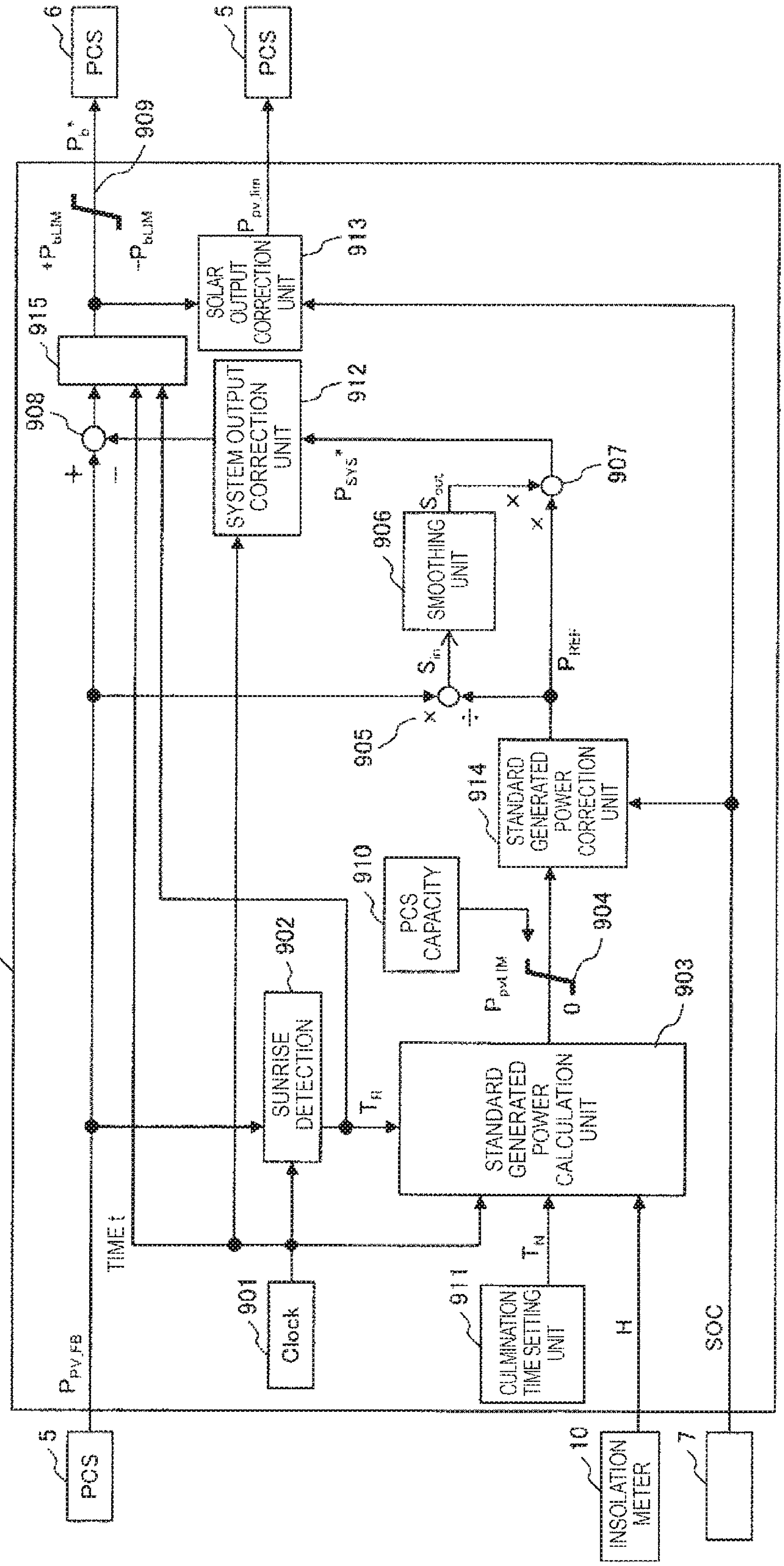
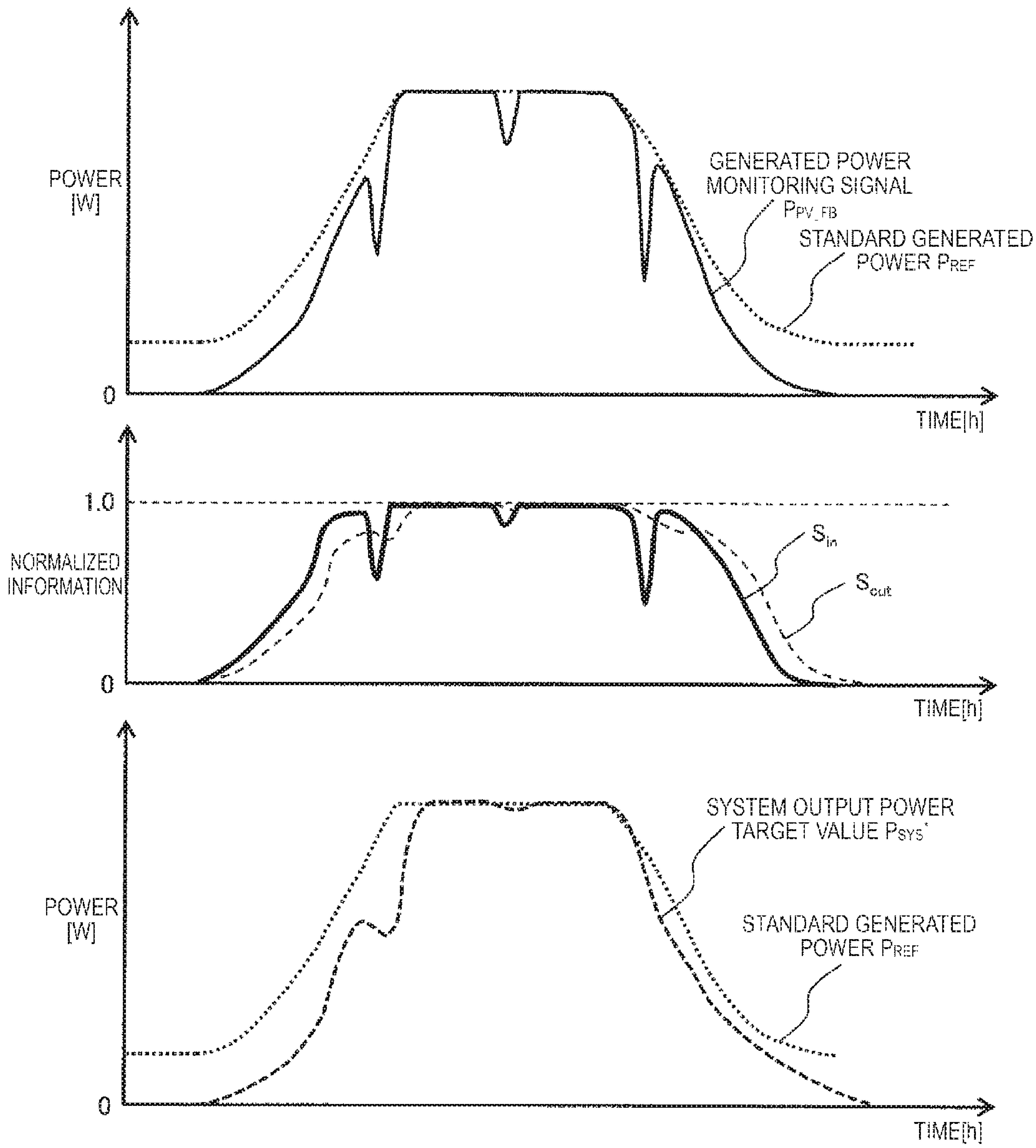

S201
ACQUIRE CURRENT TIME t AND CHARGE TARGET VALUE Pb'
S202
READ Li NIGHT SOC THRESHOLD VALUE
S203
CHARGE TARGET VALUE Pb' > Li NIGHT SOC THRESHOLD VALUE?
No
Yes
S204
CORRECT CHARGE/DISCHARGE TARGET VALUE Pb' ON THE BASIS OF DIFFERENCE BETWEEN CHARGE/DISCHARGE TARGET VALUE Pb' AND Li NIGHT SOC THRESHOLD VALUE (CALCULATE DISCHARGE ADJUSTMENT POWER PD)

Fig. 15



9
PCS
5
PCS
6
PCS
5
INSOLATION METER
10
7
Clock
901
SUNRISE DETECTION
902
STANDARD GENERATED POWER CALCULATION UNIT
903
904
905
SMOOTHING UNIT
906
907
908
909
PCS CAPACITY
910
CULMINATION TIME SETTING UNIT
911
SYSTEM OUTPUT CORRECTION UNIT
912
SOLAR OUTPUT CORRECTION UNIT
913
STANDARD GENERATED POWER CORRECTION UNIT
914
915
TIME t
H
SOC

Fig. 16



POWER [W]
0
TIME[h]
GENERATED POWER MONITORING SIGNAL P_{PV_FB}
STANDARD GENERATED POWER P_{REF}
1.0
NORMALIZED INFORMATION
0
TIME[h]
S_{in}
S_{out}
POWER [W]
0
TIME[h]
SYSTEM OUTPUT POWER TARGET VALUE P_{SYS}^*
STANDARD GENERATED POWER P_{REF}

Fig. 17

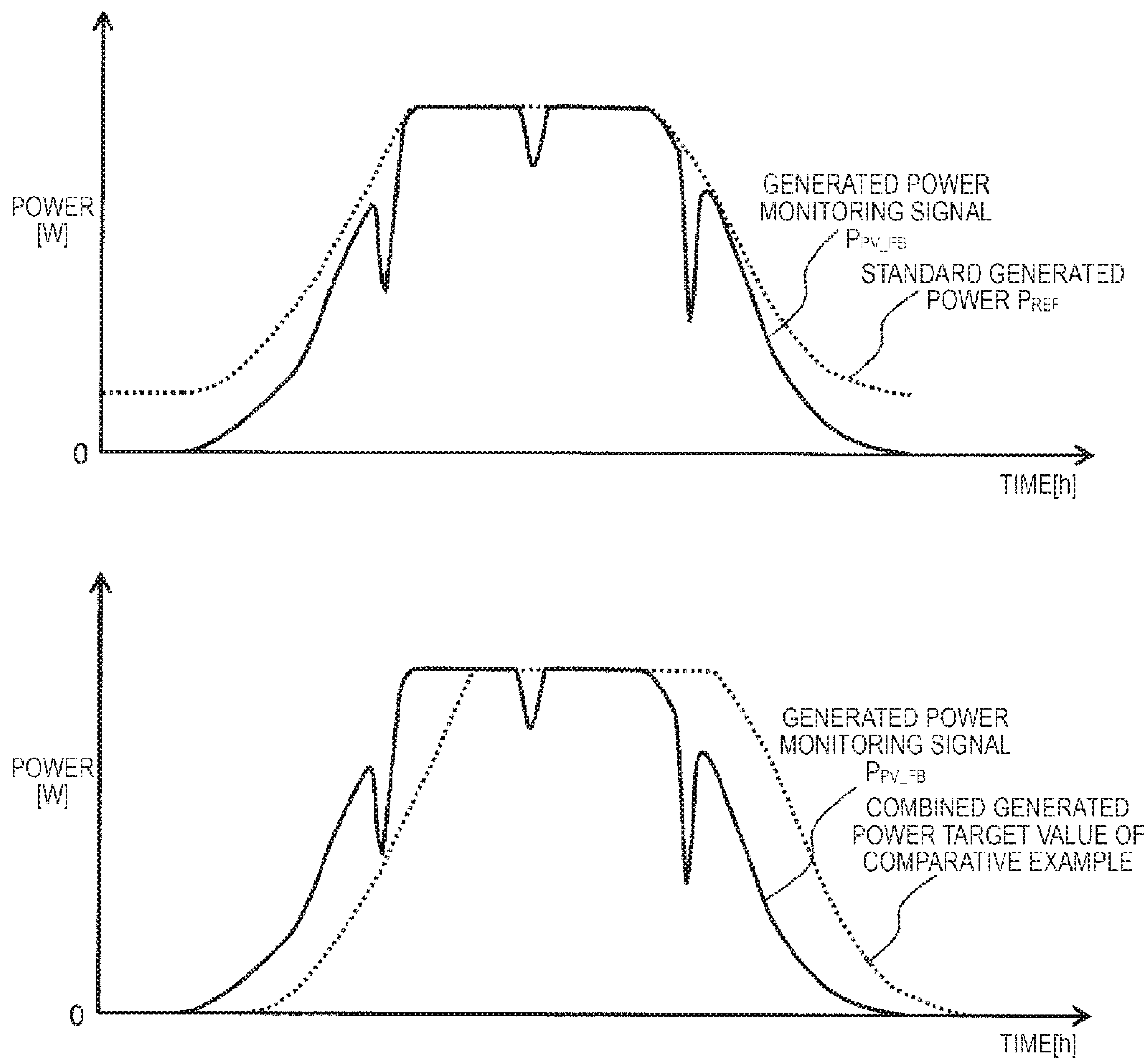
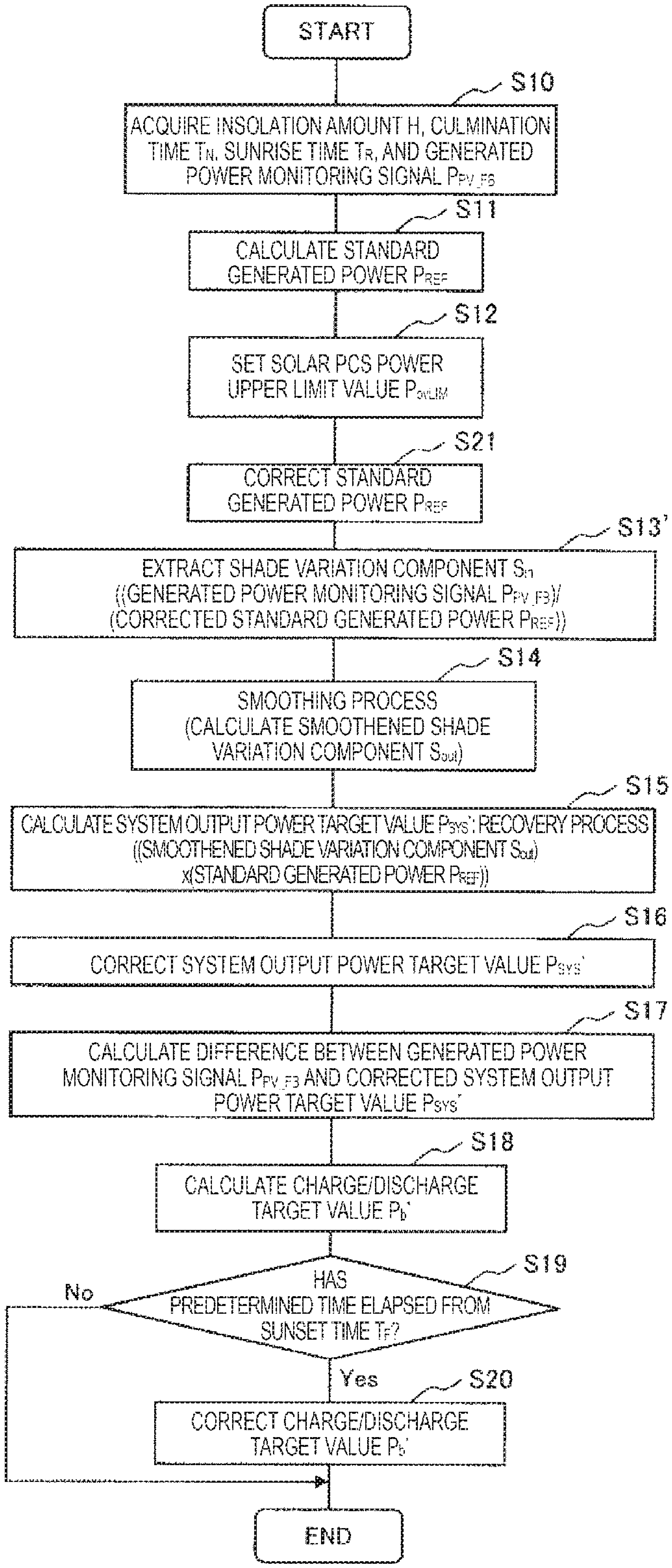

POWER [W]
0
TIME[h]
GENERATED POWER MONITORING SIGNAL P_{PV_FB}
STANDARD GENERATED POWER P_{REF}
POWER [W]
0
TIME[h]
GENERATED POWER MONITORING SIGNAL P_{PV_FB}
COMBINED GENERATED POWER TARGET VALUE OF COMPARATIVE EXAMPLE

Fig. 18


START
S10
ACQUIRE INSOLATION AMOUNT H, CULMINATION TIME T_N, SUNRISE TIME T_R, AND GENERATED POWER MONITORING SIGNAL P_{PV_F6}
S11
CALCULATE STANDARD GENERATED POWER P_{REF}
S12
SET SOLAR PCS POWER UPPER LIMIT VALUE P_{SVLIM}
S21
CORRECT STANDARD GENERATED POWER P_{REF}
S13'
EXTRACT SHADE VARIATION COMPONENT S_{in} ((GENERATED POWER MONITORING SIGNAL P_{PV_F3})/(CORRECTED STANDARD GENERATED POWER P_{REF}))
S14
SMOOTHING PROCESS (CALCULATE SMOOTHENED SHADE VARIATION COMPONENT S_{out})
S15
CALCULATE SYSTEM OUTPUT POWER TARGET VALUE P_{SYS}': RECOVERY PROCESS ((SMOOTHENED SHADE VARIATION COMPONENT S_{out}) x(STANDARD GENERATED POWER P_{REF}))
S16
CORRECT SYSTEM OUTPUT POWER TARGET VALUE P_{SYS}'
S17
CALCULATE DIFFERENCE BETWEEN GENERATED POWER MONITORING SIGNAL P_{PV_F3} AND CORRECTED SYSTEM OUTPUT POWER TARGET VALUE P_{SYS}'
S18
CALCULATE CHARGE/DISCHARGE TARGET VALUE P_b'
S19
HAS PREDETERMINED TIME ELAPSED FROM SUNSET TIME T_F?
No
Yes
S20
CORRECT CHARGE/DISCHARGE TARGET VALUE P_b'
END

STORAGE BATTERY SYSTEM AND SOLAR POWER GENERATION SYSTEM HAVING THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a solar power generation system, and particularly to a solar power generation system having a storage battery system which is suitable for minimizing a variation in solar generated power.

Background Art

In recent years, introduction of a solar power generation system has been promoted due to environmental problems and the like. However, output power generated through solar power generation greatly varies depending on the weather, and this causes a voltage variation or a frequency variation of an associated power system. As a countermeasure therefor, a storage battery system for minimizing the variation is also provided in the solar power generation system, and an output from the power system is smoothed by charging and discharging the storage battery system.

JP-A-2010-22122 has proposed such a solar power generation system. JP-A-2010-22122 discloses a configuration in which effective power output from a natural energy power source including solar power generation is detected, and a charge/discharge command value for a storage battery is obtained on the basis of a difference between the detected effective power and a combined output value which is obtained for the effective power via a change-rate limiter. In addition, a primary delay filter is provided between an effective power detector and the change-range limiter so as to smoothen an effective power detection value. Further, it is disclosed that delay operators which are connected in series to each other are provided instead of the primary delay filter, items of effective power obtained during a plurality of sampling cycles are added together, an average value thereof is obtained and is input to the change-rate limiter, and thus even in a case where an output of the natural energy power source periodically varies in a spike shape, this case is handled by reducing the capacity of the storage battery.

SUMMARY OF THE INVENTION

However, in JP-A-2010-22122, a combined output target value is calculated by obtaining a moving average of effective power from the natural energy power source by using the primary delay filter or a plurality of delay operators which are connected in series to each other. Thus, there is a deviation between the obtained combined output target value and a measured effective power profile of the natural energy power source. Charging or discharging of the storage battery is required to be performed depending on a deviation amount, and, as a result, the capacity of the storage battery is required to be secured by the deviation amount. Therefore, in the configuration disclosed in JP-A-2010-22122, there is a limitation in reduction of the capacity of the storage battery. In addition, JP-A-2010-22122 does not take into consideration, for example, a configuration in which a state of charge of the storage battery is controlled at night.

Therefore, an object of the present invention is to provide a storage battery system which can maintain performance of minimizing a solar generated power variation, reduce storage battery capacity, and lengthen the life of the storage battery, and a solar power generation system having the storage battery system.

In order to solve the above-described problems, according to an aspect of the present invention, there is provided a solar power generation system including (1) a storage battery; (2) a solar power generation device that is provided on the side of the storage battery and outputs solar generated power; and (3) a power control device. The power control device includes a variation component extraction unit that extracts a shade variation component from a generated power signal measured by the solar power generation device; a smoothing unit that smoothens the shade variation component obtained by the variation component extraction unit; a system output correction unit that obtains a system output power target value which is a combined output between a discharge output of the storage battery and the solar generated power on the basis of an output signal from the smoothing unit; and a charge/discharge output correction unit that corrects a charge/discharge target value which is a difference between the system output power target value and the generated power signal on the basis of a current time and a state of charge of the storage battery.

According to another aspect of the present invention, there is provided a storage battery system including (1) a storage battery that performs charging and discharging with solar generated power output from a solar power generation device; and (2) a power control device. The power control device includes a variation component extraction unit that extracts a shade variation component from a generated power signal measured by the solar power generation device; a smoothing unit that smoothens the shade variation component obtained by the variation component extraction unit; a system output correction unit that obtains a system output power target value which is a combined output between a discharge output of the storage battery and the solar generated power on the basis of an output signal from the smoothing unit; and a charge/discharge output correction unit that corrects a charge/discharge target value which is a difference between the system output power target value and the generated power signal on the basis of a current time and a state of charge of the storage battery.

According to still another aspect of the present invention, there is provided a power control device including a variation component extraction unit that extracts a shade variation component from a generated power signal measured by the solar power generation device; a smoothing unit that smoothens the shade variation component obtained by the variation component extraction unit; a system output correction unit that obtains a system output power target value which is a combined output between a discharge output of the storage battery and the solar generated power on the basis of an output signal from the smoothing unit; and a charge/discharge output correction unit that corrects a charge/discharge target value which is a difference between the system output power target value and the generated power signal on the basis of a current time and a state of charge of the storage battery.

According to the present invention, it is possible to provide a storage battery system which can maintain performance of minimizing a solar generated power variation, reduce storage battery capacity, and lengthen the life of the storage battery, and a solar power generation system having the storage battery system.

For example, a difference between power generated through solar power generation and a system output power target value including compensation performed by the storage battery is reduced, and thus it is possible to further reduce storage battery capacity while maintaining the performance of minimizing a variation in the solar generated power. Particularly, since a state of charge of the storage battery at night is controlled depending on characteristics of the storage battery, the life of the storage battery can be lengthened.

Objects, configurations, and effects other than the above description will become apparent through description of the following embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram schematically illustrating the entire configuration of a solar power generation system of Example 1 as one Example of the present invention.

FIG. **2** is a functional block diagram of a general controller illustrated in FIG. **1**.

FIG. **3** illustrates a temporal change of each power signal in the general controller illustrated in FIG. **2**.

FIG. **4** is a diagram illustrating a standard generated power profile obtained by a standard generated power calculation unit illustrated in FIG. **2**.

FIG. **5** is a diagram illustrating an insolation amount profile.

FIG. **6** is a diagram illustrating a screen display example of a terminal illustrated in FIG. **1**.

FIG. **7** illustrates time variations of a generated power monitoring signal and a system output power target value, and a relationship between the system output power target value, discharge adjustment power, and an SOC in Example 1.

FIG. **8** is a diagram for explaining upper limit power for forced termination determined by a system output correction unit illustrated in FIG. **2**.

FIG. **9** is a diagram illustrating an efficiency curve of a PCS for a storage battery illustrated in FIG. **2**.

FIG. **10** is a diagram illustrating a relationship between a state of charge (SOC) and a deterioration tendency of a lithium ion battery in Example 1.

FIG. **11** is a diagram illustrating a relationship between a state of charge (SOC) and a deterioration tendency of a lead storage battery in Example 1.

FIG. **12** is a flowchart illustrating processes performed by the general controller illustrated in FIG. **2**.

FIG. **13** is a flowchart illustrating a process performed by the system output correction unit illustrated in FIG. **2**.

FIG. **14** is a flowchart illustrating a process performed by a charge/discharge output correction unit illustrated in FIG. **2**.

FIG. **15** is a functional block diagram illustrating a general controller of Example 2 as another Example of the present invention.

FIG. **16** illustrates a temporal change of each power signal in the general controller illustrated in FIG. **15**.

FIG. **17** illustrates temporal changes of a generated power monitoring signal and standard generated power in Example 2 and a comparative example.

FIG. **18** is a flowchart illustrating processes performed by the general controller illustrated in FIG. **15**.

DETAILED DESCRIPTION OF THE INVENTION

In the present specification, "standard generated power P_{REF}" indicates generated power which is obtained by a solar power generation device in fine weather. In addition, a "solar panel" indicates a solar power generation device which is formed of a plurality of solar cells and outputs solar generated power.

Hereinafter, Examples of the present invention will be described with reference to the drawings.

EXAMPLE 1

FIG. **1** is a diagram schematically illustrating the entire configuration of a solar power generation system of Example 1 as one Example of the present invention. A solar power generation system **1** includes a solar panel **4** and a storage battery system **2**. The storage battery system **2** includes a storage battery **7**, a storage battery power conditioner (power conditioning system (PCS)) **6** (hereinafter, referred to as a storage battery PCS **6**), a solar power conditioner (PCS) **5** (hereinafter, referred to as a solar PCS), and a power control device **3**. The power control device **3** includes a general controller **9**, an insolation meter **10**, an external controller **11** which can perform communication with the general controller **9** via a network **8** such as the Internet, and a terminal **12** which is connected to the external controller **11** via a serial bus or a parallel bus. The solar power generation system **1** can be easily configured by connecting the storage battery system **2** to an existing or a new solar panel **4** via power lines. In addition, the solar power generation system **1** can be easily configured by connecting the power control device **3** to an equipment including the existing solar panel **4**, the storage battery **7**, the solar PCS **5**, and the storage battery PCS **6** via signal lines.

The solar panel **4** generates power by using sunlight, and solar generated power P_{PV} is converted from DC power into AC power via the solar PCS **5** constituting the storage battery system **2** and is supplied to a power system **13**. The storage battery **7** performs charging and discharging on the power system **13** with charge/discharge power P_{BATT} via the storage battery PCS **6**. As a result, a total system output P_{SYS} for the power system **13** is a combined output of the solar generated power P_{PV} and the charge/discharge power P_{BATT}, and thus a variation in the solar generated power P_{PV} due to a shade variation component such as a cloud is canceled (compensated) by the charge/discharge power P_{BATT} so that the system output P_{SYS} is smoothened. In other words, the storage battery system **2** has a function of minimizing a variation in the solar generated power P_{PV}. Here, the solar panel **4** has a configuration in which, for example, a plurality of solar cells based on silicon of the monocrystalline silicon type, the polycrystalline silicon type, the microcrystalline silicon type, or the amorphous silicon type, or based on a compound such as InGaAs, GaAs, or $CuInS_2$ (CIS) are connected in series and parallel to each other. The organic solar panel **4** using a dye sensitized solar cell or an organic thin film solar cell may be employed. The power conditioner (PCS) is referred to as a system interconnection inverter in some cases. The solar generated power P_{PV} from the solar panel **4** is limited by the capacity of the solar PCS **5** via the solar PCS **5**. For example, in a case where the solar generated power P_{PV} from the solar panel **4** is 4.2 kW, and the capacity of the solar PCS **5** is 4.0 kW, the solar generated power P_{PV} is limited to 4.0 kW via the solar PCS **5**.

The general controller **9** constituting the power control device **3**, as will be described later, calculates a system output power target value P_{SYS}* which is used as a reference for minimizing a variation, obtains a charge/discharge target value P_b* on the basis of the obtained system output power target value P_{SYS}*, and outputs the value to the storage battery PCS **6**. The general controller **9** is configured to acquire a generated power monitoring signal P_{PV_FB} which is a monitoring signal of the solar generated power P_{PV} measured by the solar PCS **5**, an insolation amount H measured by the insolation meter **10**, and a state of charge (SOC) of the storage battery **7**. The general controller **9** has a function of setting a solar generated power upper limit value P_{PV_lim} which is an upper limit value of the solar generated power P_{PV} in the solar PCS **5**. In FIG. **1**, each of the solar PCS **5** and the storage battery PCS **6** is provided alone, but the present invention is not limited thereto. For example, a large-scale solar power generation system **1** such as a mega-solar system including a plurality of solar panels **4** may have a configuration in which a plurality of solar PCSs **5** are provided in accordance with the plurality of solar panels **4**, and a plurality of storage battery PCSs **6** are provided in accordance with a plurality of storage batteries **7**. In this case, the general controller **9** calculates a sum value of the plurality of solar PCSs **5** as the system output power target value P_{SYS}*. Similarly, the general controller **9** calculates a sum value of the plurality of storage battery PCSs **6** as the charge/discharge target value P_b*. The generated power monitoring signal P_{PV_FB} may be measured by a power system or the like which is separately provided in the solar PCS **5**.

Next, a description will be made of a configuration of the general controller **9**. FIG. **2** is a functional block diagram of the general controller **9**. The general controller **9** includes a clocking unit **901**, a sunrise detection unit **902**, a standard generated power calculation unit **903**, a first upper/lower limit limiter **904**, a normalization unit **905**, a smoothing unit **906**, a recovery unit **907**, a subtractor **908**, a second upper/lower limit limiter **909**, a solar PCS power upper limit setting unit **910**, a culmination time setting unit **911**, a system output correction unit **912**, a solar output correction unit **913**, and a charge/discharge output correction unit **915**. Each of the standard generated power calculation unit **903**, the system output correction unit **912**, the solar output correction unit **913**, and the charge/discharge output correction unit **915** is constituted of, for example, a processor such as a CPU (not illustrated), and a storage portion such as a ROM and a RAM. The ROM stores a program for calculating standard generated power, a program for calculating system output correction, a program for solar output correction, and a program for calculating charge/discharge output correction. The RAM temporarily stores data which is being calculated by the processor or data used for calculation.

As illustrated in FIG. **2**, the generated power monitoring signal P_{PV_FB} measured by the solar PCS **5** branches so as to be input to the sunrise detection unit **902**, the normalization unit **905**, and the subtractor **908**. A time point t measured by the clocking unit **901** is input to the sunrise detection unit **902** and the standard generated power calculation unit **903**. The standard generated power calculation unit **903** acquires a sunrise time T_R from the sunrise detection unit **902**, and a culmination time T_N at which the sun is located at the culmination altitude from the culmination time setting unit **911**. The standard generated power calculation unit **903** acquires the insolation amount H from the insolation meter **10**. Here, the sunrise detection unit **902** outputs a time point which is stored in advance in a preset storage portion (not illustrated) to the standard generated power calculation unit **903** as the sunrise time T_R. Instead of the above-described configuration, the sunrise detection unit **902** may be configured to monitor the generated power monitoring signal P_{PV_FB} measured by the solar PCS **5**, and to obtain the sunrise time T_R with a change from rising of the generated power monitoring signal P_{PV_FB} before dawn, that is, from a zero value to a predetermined positive power as a trigger. The culmination time setting unit **911** stores a time point corresponding to the preset culmination time T_N in a storage portion (not illustrated), reads the culmination time T_N from the storage portion, and outputs the culmination time T_N to the standard generated power calculation unit **903**. Alternatively, the culmination time setting unit **911** may be configured to obtain the culmination time T_N through calculation on the basis of input latitude and longitude information of an installation location of the solar panel **4**.

The standard generated power calculation unit **903** calculates the standard generated power P_{REF} on the basis of the time point t acquired from the clocking unit **901**, the culmination time T_N obtained from the culmination time setting unit **911**, and the sunrise time T_R obtained from the sunrise detection unit **902**. The calculated standard generated power P_{REF} is limited in an upper limit value and a lower limit value thereof by the first upper/lower limit limiter **904** which is provided on the subsequent stage of the standard generated power calculation unit **903**. Here, the upper limit value and the lower limit value are set by the solar PCS power upper limit value setting unit **910** in a solar PCS power upper limit value P_{pvLIM} as the upper limit value and a zero value as the lower limit value in the first upper/lower limit limiter **904**. Here, the solar PCS power upper limit value P_{pvLIM} is set depending on the capacity of the solar PCS **5** as described above.

A description will be made of an example in which the standard generated power calculation unit **903** calculates the standard generated power P_{REF}. FIG. **4** is a diagram illustrating a standard generated power profile obtained by the standard generated power calculation unit **903**. The standard generated power P_{REF} is calculated as a curve in which 24-hour cyclic components of the solar generated power P_{PV} of that day are substantially drawn, that is, a standard generated power profile. For example, a method is known in which a solar power generation curve obtained on the basis of insolation in fine weather is defined by a trigonometric function. The standard generated power calculation unit **903** calculates the following Equation (1), and adds an offset signal P_{offset} for preventing division by zero to the calculation result so as to obtain the standard generated power P_{REF}, that is, the standard generated power profile.

$$P_{REF}(t) = X \cdot 10^{-\frac{Y}{\cos\theta(t)}} + P_{offset} \tag{1}$$

Here, $T_R \le t \le T_F$, and X, and Y are parameters which are arbitrarily set by an operator. The parameter X is a parameter contributing to an amplitude value (gain) of the standard generated power P_{REF}, and the parameter Y is a parameter contributing to a definition of duration W between the sunrise time T_R and the sunset time T_F. The parameter Y partially contributes to a definition of the amplitude value. In other words, rising of the standard generated power profile at the sunrise time T_R and falling of the standard generated power profile at the sunset time T_F are set to be rapid or smooth according to a set value of the parameter Y. An angle θ in FIG. **4** indicates an angle of sunlight which is incident to the installed solar pane **14**, that is, an angle of the sun. Therefore, θ in Equation (1) is set to −90° at the sunrise time T_R and to +90° at the sunset time T_F, and the amplitude value at the culmination time T_N is the maximum (H).

FIG. **5** illustrates an insolation amount profile. In FIG. **5**, a solid line indicates a profile of the insolation amount H measured by the insolation meter **10**, and a dotted line indicates a profile of the insolation amount H after being smoothened. The insolation profile (dotted line) after being smoothened is delayed with respect to the insolation profile (solid line) before being smoothened. The insolation amount H measured by the insolation meter **10** and indicated by the solid line in FIG. **5** exhibits an insolation amount profile to which an oscillation component with a large amplitude is added. This depends on cloud movements corresponding to a weather state, and indicates a profile which rapidly changes every hour in a day (24-hour cycle). In the example illustrated in FIG. **5**, cloud movements are large and thus the insolation amount H greatly varies. A change in solar generated power at a relatively long cycle such as being a bit cloudy may be defined by changing the parameters X and Y according to the intensity of the insolation amount H obtained from the insolation meter **10**. The standard generated power calculation unit **903** may be configured to correct the standard generated power P_{REF} on the basis of the insolation amount profile illustrated in FIG. **5**.

Referring to FIG. **2** again, the normalization unit **905** calculates a shade variation component S_{in} by dividing the generated power monitoring signal P_{PV_FB} input from the solar PCS **5** by the standard generated power P_{REF} which is calculated by the standard generated power calculation unit **903** and is obtained via the first upper/lower limit limiter **904**, and outputs the shade variation component S_{in} to the smoothing unit **906**. In other words, the shade variation component S_{in} is obtained as follows.

Shade variation component S_{in}=(generated power monitoring signal P_{PV_FB})/(standard generated power P_{REF})

The normalization unit **905** is constituted of a divider.

The smoothing unit **906** performs a smoothing process on the shade variation component S_{in} input from the normalization unit **905** so as to calculate a smoothened shade variation component S_{out} which is then output to the recovery unit **907**. Here, the smoothing unit **906** is implemented by, for example, a moving average calculation type in which a moving average is calculated by a primary delay filter or a plurality of delay operators which are connected in series to each other, or is implemented by a low-pass filter.

The recovery unit **907** obtains the system output power target value P_{SYS}* by multiplying the smoothened shade variation component S_{out} input from the smoothing unit **906** by the standard generated power P_{REF} which is calculated by the standard generated power calculation unit **903** and is obtained via the first upper/lower limit limiter **904**, and outputs the value to the system output correction unit **912**. In other words, the system output power target value P_{SYS}* is obtained as follows.

System output power target value P_{SYS}*=smoothened shade variation component S_{out}×standard generated power P_{REF}

As mentioned above, in the present example, the general controller **9** extracts the shade variation component S_{in} which is a variation factor of the solar generated power P_{PV} on the basis of the generated power monitoring signal P_{PV_FB} and the standard generated power P_{REF}, and smoothens the extracted shade variation component S_{in}. The general controller **9** obtains the system output power target value P_{SYS}* on the basis of the smoothened shade variation component S_{out} after being smoothened and the standard generated power P_{REF}, and can thus obtain the system output power target value P_{SYS}* by reflecting the shade variation component S_{in} therein.

The system output correction unit **912** performs correction calculation which will be described later in detail on the system output power target value P_{SYS}* obtained from the recovery unit **907**, and outputs the system output power target value P_{SYS}* obtained through the correction calculation to the subtractor **908**.

The subtractor **908** subtracts the corrected system output power target value P_{SYS}* which is output from the system output correction unit **912** from the generated power monitoring signal P_{PV_FB} which is input from the solar PCS **5**, so as to obtain the charge/discharge target value P_b*. The obtained charge/discharge target value P_b* is output to the charge/discharge output correction unit **915** disposed between the subtractor **908** and the second upper/lower limit limiter **909**.

The charge/discharge output correction unit **915** performs correction calculation which will be described later in detail on the input charge/discharge target value P_b*, and outputs the corrected charge/discharge target value P_b* obtained through the correction calculation to the second upper/lower limit limiter **909** which is provided in the subsequent stage. The charge/discharge target value P_b* whose upper limit value and lower limit value are limited in the second upper/lower limit limiter **909** is output to the storage battery PCS **6**. Here, a storage battery PCS power upper limit value $+P_{bLIM}$ and a storage battery PCS power lower limit value $-P_{bLIM}$ which are set in the second upper/lower limit limiter **909** are set to, for example, values corresponding to limit power of charging or discharging of the storage battery **7** or the storage battery PCS **6**.

The solar output correction unit **913** acquires a state of charge (SOC) from the storage battery **7** and also acquires the corrected charge/discharge target value P_b* output from the charge/discharge output correction unit **915**. At this time, in a case where a variation in the system output P_{SYS} illustrated in FIG. **1** is hard to sufficiently minimize, such as a case where the state of charge (SOC) of the storage battery **7** is reduced, the solar output correction unit **913** reduces the upper limit value P_{PV_lim} of the solar generated power P_{PV} in advance, and outputs the reduced upper limit value P_{PV_lim} to the solar PCS **5**.

The above-described solar PCS power upper limit setting unit **910** may set a value which is conjunct with a variation in the upper limit value P_{PV_lim} of the solar generated power P_{PV} in the solar output correction unit **913**, as the solar PCS power upper limit value P_{pvLim} in the first upper/lower limit limiter **904**. The standard generated power calculation unit **903** may be configured to have a function of incorporating weather data.

Here, FIG. **3** illustrates a temporal change of each power signal in the general controller **9** illustrated in FIG. **2**. On an upper part of FIG. **3**, a temporal change of the generated power monitoring signal P_{PV_FB} input from the solar PCS **5** is indicated by a solid line, and a temporal change of the standard generated power P_{REF} which is calculated by the standard generated power calculation unit **903** and is obtained via the first upper/lower limit limiter **904** is indicated by a dotted line. On an intermediate part thereof, a temporal change of the shade variation component S_{in} output from the normalization unit **905** is indicated by a solid line, and a temporal change of the smoothened shade variation component S_{out} output from the smoothing unit **906** is indicated by a dotted line. On a lower part thereof, a temporal change of the system output power target value P_{SYS}* output from the recovery unit **907** is indicated by a thick dotted line, and a temporal change of the standard generated power P_{REF} which is calculated by the standard generated power calculation unit **903** and is obtained via the first upper/lower limit limiter **904** is indicated by a dotted line. As illustrated on the upper part of FIG. **3**, a variation in the generated power monitoring signal P_{PV_FB} exhibits a waveform in which a shade variation component for a short period of time is superimposed on a large variation component in a 24-hour cycle, that is, during the morning, the afternoon, and the night. It can be seen that the shade variation component S_{in} obtained by the normalization unit **905** is located around 1.0 for most of the time as illustrated on the intermediate part of FIG. **3**, and thus only the shade variation component is extracted by removing the variation component in the 24-hour cycle. It can be seen that the smoothing unit **906** performs the above-described smoothing process on only the shade variation component S_{in} obtained in the above-described way, and thus the system output power target value P_{SYS}* which is not delayed relative to the variation component in the 24-hour cycle is obtained by the recovery unit **907** as illustrated on the lower part of FIG. **3**.

FIG. **6** is a diagram illustrating a screen display example of the terminal **12** illustrated in FIG. **1**. As illustrated in FIG. **6**, a screen **20** of a display device of the terminal **12** includes a first display region **21**, a second display region **22**, a parameter input region **23**, a history designation input region **24**, a history display type designation input region **25**, and an execution button **26**.

As illustrated in FIG. **6**, a system diagram of the solar power generation system is displayed on the second display region **22**. In the example illustrated in FIG. **6**, in the displayed system diagram, the solar generated power P_{PV} is supplied to the power system by a mega-solar system (large-scale solar power generation system) including a plurality of solar panels, a plurality of solar PCSs, a plurality of storage batteries, a plurality of storage battery PCSs, and general controllers (Cont) provided at the respective solar panels, and a solar power generation system connected to the mega-solar system via a network.

The history display type designation input region **25** is a region which allows an operator's designation on the type whose history is to be displayed in the first display region **21**, to be input. In the example illustrated in FIG. **6**, a state is displayed in which "generated power result history" and "insolation profile history" are displayed as the type, and the "generated power result history" is designated by the operator.

The history designation input region **24** is a region which allows the operator to select and designate a desired period among the present and past results displayed in the first display region **21** in relation to the type designated in the history display type designation input region **25**. Pull-down buttons are provided on a right column of the history designation input region **24**. The operator can designate a desired period by using the pull-down buttons. A blank column is provided among options using the pull-down button, and the operator may input a desired period for himself/herself with an input device such as a keyboard or a mouse (not illustrated) after designating the blank column. In the example illustrated in FIG. **6**, a state is illustrated in which "the present", "one year ago", and "two years ago" are designated. A period in which designated history is to be displayed is not limited to the designation of every year, and may be, for example, "the present", "yesterday", and "the day before yesterday". However, regarding designation of seasons, the insolation amount H greatly differs for each season, and thus a period in the same season is preferably designated.

As described above, if the "generated power result history" is designated in the history display type designation input region **25**, and "the present", "one year ago", and "two years ago" are designated in the history designation input region **24**, a profile of a solar generated power result corresponding to each item is displayed in the first display region **21** so as to be referred to. Consequently, the operator can set the parameters X and Y in the above Equation (1) to desired values by referring to the system diagram of the solar power generation system displayed in the second display region **22** and the solar generated power profiles corresponding to "the present", "one year ago", and "two years ago" displayed in the first display region **21**. The parameters X and Y are set by using the parameter input region **23**. In the same manner as the history designation input region **24**, pull-down buttons are provided on the right column of the parameter input region **23**. The operator selects and designates desired values among a plurality of values which are prepared as options in advance by using the pull-down buttons. A blank column may be provided among the options, and a desired value may be input by the operator by designating the blank column. FIG. **6** illustrates a state in which "abc" is set as the parameter X, and "efg" is set as the parameter Y. If the operator's input operation on the execution button **26** is received in this state, the terminal **12** transmits the set parameters X and Y to the general controller **9** via the external controller **11** and the network **8**. If the parameters X and Y are received via a communication interface (not illustrated), the general controller **9** stores the parameters in a storage portion (not illustrated) of the standard generated power calculation unit **903**, and performs calculation according to the above Equation (1) by using the stored parameters X and Y so as to calculate the standard generated power P_{REF} as described above. A storage portion storing the parameters X and Y is not limited to the storage portion in the standard generated power calculation unit **903**, and may be an external storage portion. A case where the "generated power result history" is designated has been described as an example in FIG. **6**, but, similarly, also in a case where the "insolation profile history" is designated, the insolation profile history is displayed in the first display region **21**. The history display type designation input region **25** may allow both of the "generated power result history" and the "insolation profile history" to be designated. In this case, both of the generated power result history and the insolation profile history are displayed in the first display region **21**.

FIG. **7** illustrates temporal changes of the generated power monitoring signal P_{PV_FB} and the system output power target value P_{SYS}*, and a relationship between the system output power target value P_{SYS}, discharge adjustment power P_D, and a state of charge (SOC). If a low-pass filter is used in the smoothing unit **906**, the storage battery **7** tends to be discharged due to an influence of a delay component of the filter before and after sunset (before and after the sunset time T_F), and thus there is a probability that the SOC of the storage battery **7** may be an over discharge state at night. Since the life of the storage battery **7** can be lengthened when the SOC thereof is maintained within an appropriate range, it is possible to achieve an effect of lengthening the life of the storage battery **7** if the SOC which is maintained to be constant at night can be made within an appropriate range. Therefore, for example, as indicated by a forced termination upper limit power P_{F_LIM} on an upper part of FIG. **7**, a ramp upper limit value which is **0** at a time point (time point T_{F1}) before the sunset time T_F is set, and is stored in a storage portion (not illustrated) of the system output correction unit **912** in advance.

The system output correction unit **912** compares the system output power target value P_{SYS}* input from the recovery unit **907** with the forced termination upper limit power P_{F_LIM} stored in the storage portion (not illustrated). As a result of the comparison, if the system output power target value P_{SYS} exceeds the forced termination upper limit power P_{F_LIM}, the system output correction unit **912** corrects the system output power target value P_{SYS}* so as to match the forced termination upper limit power P_{F_LIM}. As a result, the SOC of the storage battery **7** can be maintained to be high without reaching an over discharge state.

In a case where there is a deviation relative to an SOC level (hereinafter, referred to as a target SOC level) in which the life of the storage battery **7** is further lengthened, the charge/discharge output correction unit **915** corrects the charge/discharge target value P_b* so that the storage battery **7** performs additional discharge by the discharge adjustment power P_D illustrated in FIG. **7** at a predetermined time point after sunset (later than the sunset time T_F). Consequently, an SOC level of the storage battery **7** can be caused to reach the target SOC level. In FIG. **7**, the forced termination upper limit power P_{F_LIM} and the discharge adjustment power P_D are changed at specific change rates a_{F1}, a_{F2}, and a_{R2}, but if the change rates are appropriately selected according to, for example, power variation regulations of a predetermined power transmission operating agency which manages the power system **13**, it is possible to adjust an SOC without deteriorating the performance of minimizing a variation in the solar generated power P_{PV}.

In the storage battery **7**, inherently, the number of times of charge and discharge (cycle of charge and discharge) is inversely proportional to the storage battery life. As illustrated on the lower part of FIG. **7**, the cycle of charge and discharge increases due to the storage battery **7** being discharged by ΔE after a predetermined time elapsed (night) from the sunset time T_F. However, the number of operations for reduction to the target SOC is only one after the sunset time T_F in a day. Therefore, the storage battery **7** is hardly influenced by the increase in the cycle of charge and discharge, and rather it is possible to prevent a deterioration phenomenon of the storage battery **7** occurring due to a high SOC state being maintained. This is considerably effective in a case where a lithium ion battery is used as the storage battery **7**, and the same effect can also be achieved in a case where other storage batteries are used.

FIG. **8** is a diagram for explaining the forced termination upper limit power P_{F_LIM} determined by the system output correction unit **912**. The system output correction unit **912** acquires a time point t (current time) from the clocking unit **901** at a predetermined interval, for example, at the interval of 1 sec, and also acquires the system output power target value P_{SYS}* output from the recovery unit **907**. As illustrated in FIG. **8**, the system output correction unit **912** obtains a tangential line which passes through the system output power target value P_{SYS}* at a time point T_1 and calculates angles a' formed with the time axis in a sequential manner (every cycle) on the basis of profiles of the system output power target value P_{SYS}* at the time point T_1 and the system output power target value P_{SYS}* at a predetermined time before the time point T_1. The system output correction unit **912** calculates the change rate a_{F1} every time on the basis of the calculated angle a', and obtains and sets the forced termination upper limit power P_{F_LIM}. Therefore, the forced termination upper limit power P_{F_LIM} exhibits a value which changes for every predetermined cycle.

FIG. **8** illustrates a state in which the tangential line at the time point T_1 also passes through the system output power target value P_{SYS}* at a time point T_2 after N hours elapse from the time point T_1. Therefore, the forced termination upper limit power P_{F_LIM} at the time point T_1 is the same as that at the time point T_2. For convenience of description, FIG. **8** illustrates that the storage battery **7** is charged with charging power P_c corresponding to an area of a hatched region assuming that the forced termination upper limit power P_{F_LIM} which is calculated on the basis of the system output power target value P_{SYS}* at the time point T_1 is set to a fixed value. The forced termination upper limit power P_{F_LIM} which is calculated for every predetermined cycle sequentially changes according to a variation in the system output power target value P_{SYS}* in the 24-hour cycle.

As illustrated in FIG. **8**, the system output correction unit **912** determines the slope a_{F1} of the forced termination upper limit power P_{F_LIM} so that the slope is greater than the angle a' in order to secure a charging amount. If a_{F1}<a', the charging power P_c for the storage battery **7** is "0", but if a_{F1}>a', the storage battery **7** is charged with the charging power P_c corresponding to the area of the hatched region as described above. Consequently, it is possible to handle a steep variation in the solar generated power P_{PV} in a day. FIG. **8** shows the forced termination upper limit power P_{F_LIM} as a simplified straight line as an example, but the present invention is not limited thereto. For example, the forced termination upper limit power P_{F_LIM} may be defined by using a curve corresponding to a slope (a_{F1}) which is sequentially updated.

FIG. **9** is a diagram illustrating an efficiency curve of the storage battery PCS illustrated in FIG. **2**. An output from the storage battery PCS **6** is limited depending on the capacity of the storage battery PCS as described above. As illustrated in FIG. **9**, an output upper limit value from the storage battery PCS **6** is defined as P_{Dmax}. As illustrated in FIG. **7**, the system output power target value P_{SYS}* exhibits a trapezoidal waveform profile having change rates a_{F2} and a_{R2} after a predetermined time elapses (night) from the sunset time T_F. An upper bottom of the trapezoidal waveform profile is constant, and thus the system output power target value P_{SYS}* at this upper bottom is adjusted to the output P_{Dmax} which brings the storage battery PCS **6** to the maximum efficiency. The storage battery **7** is discharged by the discharge adjustment power P_D defined by an area of the trapezoidal waveform profile, and thus it is possible to achieve an effect of reducing system loss. This is because, in a case where the storage battery **7** is charged and discharged, conversion efficiency of the storage battery PCS **6** is associated with a system loss ratio. Therefore, the storage battery is charged and discharged around the output P_{Dmax} which brings the storage battery PCS **6** to the maximum efficiency, and thus the system loss can be reduced.

FIG. **10** is a diagram illustrating a relationship between a state of charge (SOC) and a deterioration tendency of a lithium ion battery (Li ion battery). The Li ion battery has a tendency that a forming speed of a solid electrolyte interface (SEI) as a coating film which inactivates and stabilizes a surface of graphite in a high SOC region is heightened. For this reason, there is a concern that preservation deterioration is accelerated. Therefore, the SOC is preferably maintained to be 30% or less after a predetermined time elapses (night) from the sunset time T_F. On the other hand, if the SOC is maintained in a state of 0%, it is hard to handle an abrupt discharge command at night. As mentioned above, in a case where the Li ion battery is used as the storage battery **7**, the SOC is preferably maintained in a range from 20% to 30% at night.

Therefore, in the present example, in a case where a Li ion battery is used as the storage battery **7**, a threshold value (hereinafter, referred to as a Li night SOC threshold value) is set within a range of the SOC from 20% to 30% after a predetermined time elapses (night) from the sunset time T_F, and the Li night SOC threshold value is stored in a storage portion (not illustrated) of the charge/discharge output correction unit **915**. Here, the Li night SOC threshold value corresponds to an SOC which is reduced by ΔE due to an effect of the discharge adjustment power P_D illustrated on the lower part of FIG. **7**. In addition, not only the set Li night SOC threshold value but also the relationship between an SOC and a deterioration tendency of the Li ion battery illustrated in FIG. **10** may be stored in a storage portion (not illustrated).

FIG. **11** is a diagram illustrating a relationship between a state of charge (SOC) and a deterioration tendency of a lead storage battery. The lead storage battery has characteristics in which preservation deterioration is rather minimized in a high SOC region unlike the Li ion battery. This is because lead sulfate generated during reaction is crystallized through repeated dissolution and deposition, and this may prevent a chargeable state from occurring. Therefore, the SOC is preferably maintained in a range from 90% to 100% after a predetermined time elapses (nighttime) from the sunset time T_F. As described above, in a case where the lead storage battery is used as the storage battery **7**, the SOC is preferably maintained in a range from 90% to 100% at night.

Therefore, in the present example, in a case where a lead storage battery is used as the storage battery **7**, a threshold value (hereinafter, referred to as a Pb night SOC threshold value) is set within a range of the SOC from 90% to 100% after a predetermined time elapses (night) from the sunset time T_F, and the Pb night SOC threshold value is stored in the storage portion (not illustrated) of the charge/discharge output correction unit **915**. However, the SOC scarcely reaches 90% or higher at night. Thus, in a case where the lead storage battery is used, discharge control at night is not performed, that is, the storage battery **7** is not discharged by the discharge adjustment power P_D. In addition, not only the Pb night SOC threshold value but also the relationship between an SOC and a deterioration tendency of the lead ion battery illustrated in FIG. **11** may be stored in a storage portion (not illustrated).

Next, a description will be made of a flow of a series of processes performed by the general controller **9**. FIG. **12** is a flowchart illustrating processes performed by the general controller **9**.

The standard generated power calculation unit **903** constituting the general controller **9** acquires the insolation amount H, the culmination time T_N, the sunrise time T_R, and the generated power monitoring signal P_{PV_FB} (step S**10**).

The standard generated power calculation unit **903** calculates the standard generated power P_{REF} by using the above Equation (1) (step S**11**). In step S**12**, the solar PCS power upper limit setting unit **910** sets the solar PCS power upper limit value P_{pvLIM} in the first upper/lower limit limiter **904**.

In step S**13**, the normalization unit **905** divides the generated power monitoring signal P_{PV_FB} by the standard generated power P_{REF} which is obtained via the first upper/lower limit limiter **904**, so as to extract the shade variation component S_{in}. In step S**14**, the smoothing unit **906** performs a smoothing process on the shade variation component S_{in} obtained in step S**13**, so as to calculate the smoothened shade variation component S_{out}.

In step S**15**, the recovery unit **907** multiplies the smoothened shade variation component S_{out} obtained in step S**14** by the standard generated power P_{REF} obtained via the first upper/lower limit limiter **904**, so as to calculate the system output power target value P_{SYS}*. Successively, the system output correction unit **912** corrects the system output power target value P_{SYS}* which is input from the recovery unit **907** on the basis of a time point t (the current time) acquired from the clocking unit **901** (step S**16**).

Next, the subtractor **908** calculates a difference between the generated power monitoring signal P_{PV_FB} and the corrected system output power target value P_{SYS}* obtained in step S**16** (step S**17**). The difference obtained in step S**17** is input to the charge/discharge output correction unit **915** as the charge/discharge target value P_b* (step S**18**).

Next, in step S**19**, the charge/discharge output correction unit **915** receives a time point t (current time) from the clocking unit **901** and also receives the sunrise time T_R from the sunrise detection unit **902**, so as to determine whether or not a predetermined time has elapsed from the sunset time T_F. If the predetermined time has not elapsed as a result of the determination, the charge/discharge target value P_b* which is input in step S**18** is output to the storage battery PCS **6** via the second upper/lower limit limiter **909**. On the other hand, if the predetermined time has elapsed from the sunset time T_F as a result of the determination, the flow proceeds to step S**20**.

In step S**20**, the charge/discharge output correction unit **915** corrects the charge/discharge target value P_b* which is input in step S**18**. The corrected charge/discharge target value P_b* is output to the storage battery PCS **6** via the second upper/lower limit limiter **909**.

A control cycle in the general controller **9** has, for example, an order of several seconds (for example, 1 sec), and the processes from step S**10** to step S**20** are performed in this control cycle.

Here, a description will be made of the process of correcting the system output power target value P_{SYS}* in step S**16** illustrated in FIG. **12**. FIG. **13** is a flowchart illustrating a process performed by the system output correction unit **912**. In step S**161**, the system output correction unit **912** acquires the current time t from the clocking unit **901** and the system output power target value P_{SYS}* from the recovery unit **907**. In step S**162**, the system output correction unit **912** generates a tangential line which passes through the system output power target value P_{SYS}* at the current time t on the basis of a profile of the system output power target value P_{SYS}* at a predetermined time before the current time t.

In step S**163**, the system output correction unit **912** calculates an angle a' (FIG. **8**) formed between the generated tangential line and the time axis. A change rate a_{F1} is calculated on the basis of the calculated angle a' (step S**164**). Next, the forced termination upper limit power P_{F_LIM} is calculated on the basis of the calculated change rate a_{F1} (step S**165**). The system output correction unit **912** combines the obtained forced termination upper limit power P_{F_LIM} with the system output power target value P_{SYS}* before the current time t so as to generate a corrected system output power target value P_{SYS}* (step S**166**).

A description will be made of the process of correcting the charge/discharge target value P_b* in step S**20** illustrated in FIG. **12**. FIG. **14** is a flowchart illustrating a process performed by the charge/discharge output correction unit **915**. The charge/discharge output correction unit **915** acquires the current time t from the clocking unit **901**, and the charge/discharge target value P_b* which is obtained as a difference between the generated power monitoring signal

P_{PV_FB} and the corrected system output power target value P_{SYS}*, from the subtractor **908** (step S**201**). In step S**202**, the charge/discharge output correction unit **915** reads a Li night SOC threshold value stored in the storage portion (not illustrated). In step S**203**, it is determined whether or not the charge/discharge target value P_b* is greater than the Li night SOC threshold value. If the charge/discharge target value P_b* is equal to or smaller than the Li night SOC threshold value as a result of the determination, the process is finished. On the other hand, if charge/discharge target value P_b* is greater than the Li night SOC threshold value as a result of the determination, the flow proceeds to step S**204**. In step S**204**, the charge/discharge target value is corrected by using a difference between the charge/discharge target value P_b* and the Li night SOC threshold value. Consequently, the discharge adjustment power P_D is calculated, and the Li ion battery used as the storage battery **7** is set to a value which is reduced to the Li night SOC threshold value or smaller through discharge control.

In FIG. **14**, a case where a Li ion battery is used as the storage battery **7** has been described as an example, but, also in a case where a lead storage battery is used, similarly, the charge/discharge target value P_b* is corrected through comparison with the above-described Pb night SOC threshold value. In the present example, a case where a Li ion battery or a lead storage battery is used as the storage battery **7** has been described as an example, but the present invention is not limited thereto. For example, in a mega-solar system, both a Li ion battery and a lead storage battery may be used. In this case, the charge/discharge output correction unit **915** constituting the general controller **9** may store a Li night SOC threshold value and a Pb night SOC threshold value in a storage portion (not illustrated) and perform the above-described process of correcting the charge/discharge target value P_b*.

In the present example, the terminal **12** is connected to the external controller **11** which is connected to the general controller **9** via the network **8**, but the present invention is not limited thereto, and the terminal **12** may be connected to the general controller **9** via a serial bus or a parallel bus.

As described above, according to the present example, a shade variation component is extracted, and a smoothing process (a primary delay filter or the like) is performed on only the extracted shade variation component. Thus, it is possible to reduce a difference between the standard generated power P_{REF} and the system output power target value P_{SYS}*. Consequently, the charge/discharge target value P_b* for the storage battery is optimized, and thus it is possible to reduce storage battery capacity while maintaining the performance of minimizing a variation in the solar generated power P_{PV}. Particularly, since a state of charge (SOC) of the storage battery in the nighttime is controlled depending on characteristics of the storage battery, the life of the storage battery can be lengthened.

EXAMPLE 2

FIG. **15** is a functional block diagram illustrating a general controller of Example 2 as another Example of the present invention. The present example is different from Example 1 in that the general controller **9** additionally includes a standard generated power correction unit **914** which corrects the standard generated power P_{REF} in the subsequent stage of the first upper/lower limit limiter **904** on the basis of a state of charge (SOC) from the storage battery **7**, and the solar PCS **5** whose rating output is designed to be lower than the maximum power of the solar panel **4** is used. Other configurations are the same as those in the above Example 1, and description overlapping that in Example 1 will not be repeated.

In FIG. **15**, the standard generated power correction unit **914** corrects the standard generated power P_{REF} which is calculated by the standard generated power calculation unit **903** and is obtained via the first upper/lower limit limiter **904**, on the basis of a state of charge (SOC) acquired from the storage battery **7**. For example, if the acquired state of charge (SOC) is high, the standard generated power correction unit **914** corrects the parameters X and Y in the above Equation (1) so as to correct the standard generated power P_{REF}, and thus adjusts a difference between the solar generated power P_{PV} and the system output P_{SYS}. Since there is a tendency for SOC likelihood to be restricted if a power amount of the storage battery **7** is minimized, the power amount of the storage battery **7** can be reduced by controlling the state of charge (SOC) within an appropriate range. An output from the standard generated power correction unit **914** branches so as to be input to the normalization unit **905** and the recovery unit **907**.

Here, FIG. **16** illustrates a temporal change of each power signal in the general controller **9**. On an upper part of FIG. **16**, a temporal change of the generated power monitoring signal P_{PV_FB} input from the solar PCS **5** is indicated by a solid line, and a temporal change of the standard generated power P_{REF} which is calculated by the standard generated power calculation unit **903** (FIG. **15**) and is obtained via the first upper/lower limit limiter **904** (FIG. **15**) is indicated by a dotted line. On an intermediate part thereof, a temporal change of the shade variation component S_{in}, output from the normalization unit **905** (FIG. **15**) is indicated by a solid line, and a temporal change of the smoothened shade variation component S_{out} output from the smoothing unit **906** (FIG. **15**) is indicated by a dotted line. On a lower part thereof, a temporal change of the system output power target value P_{SYS}* output from the recovery unit **907** (FIG. **15**) is indicated by a thick dotted line, and a temporal change of the standard generated power P_{REF} which is calculated by the standard generated power calculation unit **903** and is obtained via the first upper/lower limit limiter **904** is indicated by a dotted line.

The solar PCS **5** of the present example is designated to have rating power lower than the maximum power of the solar panel **4**. Therefore, as illustrated on the upper part of FIG. **16**, the generated power monitoring signal P_{PV_FB} which is a monitoring signal of the solar generated power P_{PV} measured by the solar PCS **5** tends to have a profile whose top is flat since a peak of the solar generated power P_{PV} is cut. The solar PCS power upper limit setting unit **910** sets the solar PCS power upper limit value P_{pvLIM} corresponding to the rating power of the solar PCS **5** in the first upper/lower limit limiter **904**. Consequently, the standard generated power P_{REF} calculated by the standard generated power calculation unit **903** is limited by the first upper/lower limit limiter **904**. A profile of the standard generated power P_{REF} having passed through the first upper/lower limit limiter **904** becomes a profile whose top is flat in the same manner as in the generated power monitoring signal P_{PV_FB} as illustrated on the upper part of FIG. **16**.

In profiles of the shade variation component S_{in} obtained by the normalization unit **905** and the smoothened shade variation component S_{out} obtained by the smoothing unit **906**, in the same manner as in Example 1 (FIG. **3**), only a shade variation component is extracted by removing a variation component in the 24-hour cycle as illustrated on the intermediate part of FIG. **16**. As mentioned above, the smoothing unit **906** performs the smoothing process described in Example 1 on only the shade variation component S_{in}, and thus the system output power target value P_{SYS}* which is not delayed relative to the variation component in the 24-hour cycle is obtained as illustrated on the lower part of FIG. **16**. Therefore, the profile of the system output power target value P_{SYS}* also becomes a profile whose top is flat.

Here, FIG. **17** illustrates temporal changes of a generated power monitoring signal and standard generated power in the present example and a comparative example. A configuration of the comparative example is the same as the configuration disclosed in JP-A-2010-22122. An upper part of FIG. **17** illustrates the profiles of the generated power monitoring signal P_{PV_FB} and the standard generated power P_{REF} illustrated on the upper part of FIG. **16**. A lower part of FIG. **17** illustrates profiles of a combined generated power target value and the generated power monitoring signal P_{PV_FB} in the comparative example, corresponding to the standard generated power P_{REF} of the present example.

As illustrated in FIG. **17**, in the configuration of the comparative example, it can be seen that a deviation between the combined generated power target value and the generated power monitoring signal P_{PV_FB} increases. In other words, the combined generated power target value of the comparative example has a profile in which there is a delay relative to a variation component of the generated power monitoring signal P_{PV_FB} in the 24-hour cycle. If the deviation increases as mentioned above, this naturally influences the system output power target value P_{SYS} illustrated in FIG. **16**. In contrast, in the present example, it can be seen that a deviation between the generated power monitoring signal P_{PV_FB} and the standard generated power P_{REF} is minimized, and thus the standard generated power P_{REF} is obtained which is not delayed relative to the variation component of the generated power monitoring signal P_{PV_FB} in the 24-hour cycle.

Consequently, the deviation is reduced compared with the configuration of the comparative example. Therefore, according to the present example, it is possible to reduce an influence on the system output power target value P_{SYS}*. In other words, an error component in the normalization unit **905** is minimized and thus unnecessary charge and discharge in the storage battery **7** are reduced. Therefore, the capacity of the storage battery **7** can be more considerably reduced than in the configuration of the comparative example. In other words, it is possible to achieve an effect of being capable of minimizing power and a power amount of the storage battery **7**.

Here, a description will be made of a flow of processes performed by the general controller **9**. FIG. **18** is a flowchart illustrating processes performed by the general controller **9** illustrated in FIG. **15**. First, steps S**10** to S**12** are the same as those illustrated in FIG. **12** in Example 1.

In step S**21**, the standard generated power correction unit **914** acquires the standard generated power P_{REF} which has passed the first upper/lower limit limiter **904** in which the solar PCS power upper limit value P_{pvLIM} is set by the solar PCS power upper limit setting unit **910** in step S**12**. The standard generated power correction unit **914** acquires a state of charge (SOC) from the storage battery **7**, corrects the standard generated power P_{REF} on the basis of the acquired SOC, and outputs the corrected standard generated power P_{REF} to the normalization unit **905** and the recovery unit **907**.

In step S**13**', the normalization unit **905** divides the generated power monitoring signal P_{PV_FB} measured by the solar PCS **5** by the corrected standard generated power P_{REF} output from the standard generated power correction unit **914** so as to extract the shade variation component S_{in}. In other words, the shade variation component S_{in} is obtained as follows.

Shade variation component S_{in}=(generated power monitoring signal P_{PV_FB})/(corrected standard generated power P_{REF})

Steps S**14** to S**20** are the same as those illustrated in FIG. **12** in Example 1 and thus description thereof will be omitted.

As mentioned above, according to the present example, the standard generated power correction unit corrects the standard generated power on the basis of an SOC of the storage battery, and thus it is possible to reduce the capacity of the storage battery more than in the configuration of Example 1. The solar PCS which is designed to have a low rating output is used, and thus it is also possible to reduce an equipment investment cost for the PCS.

The present invention is not limited to the above-described Examples and includes various modifications. For example, the above Examples have been described in detail for better understanding of the present invention, and are not necessarily limited to including all the configurations described above. Some configurations of certain Examples may be replaced with configurations of other Examples, and the configurations of other Examples may be added to the configuration of certain Examples. The configurations of other Examples may be added to, deleted from, and replaced with some of the configurations of each Example.

What is claimed is:

1. A solar power generation system comprising:
a storage battery;
a solar power generation device that is provided on the side of the storage battery and outputs solar generated power; and
a power control device,
wherein the power control device includes
a variation component extraction unit that extracts a shade variation component from a generated power signal measured by the solar power generation device;
a smoothing unit that smoothens the shade variation component obtained by the variation component extraction unit;
a system output correction unit that obtains a system output power target value which is a combined output between a discharge output of the storage battery and the solar generated power on the basis of an output signal from the smoothing unit; and
a charge/discharge output correction unit that corrects a charge/discharge target value which is a difference between the system output power target value and the generated power signal on the basis of a current time and a state of charge of the storage battery.

2. The solar power generation system according to claim **1**,
wherein the power control device further includes a standard generated power calculation unit that obtains generated power obtained by the solar power generation device in fine weather as standard generated power, and
wherein the variation component extraction unit extracts the shade variation component on the basis of the generated power signal and the standard generated power.

3. The solar power generation system according to claim 2,

wherein the charge/discharge output correction unit holds a threshold value of the state of charge in a preset nighttime period, and corrects the charge/discharge target value in a case where the current time is the set nighttime period and the state of charge of the storage battery exceeds the threshold value.

4. The solar power generation system according to claim 3,

wherein the charge/discharge output correction unit holds information for defining different correspondence relationships between states of charge and deterioration tendencies depending on the type of storage battery, and sets a threshold value of the state of charge on the basis of the correspondence relationships between the states of charge and the deterioration tendencies.

5. The solar power generation system according to claim 3,

wherein the system output correction unit calculates a change rate of a system output power target value at the current time on the basis of a current value and a system output power target value at a predetermined time before the current time among the system output power target values obtained in a predetermined cycle, obtains forced termination upper limit power having a change rate which is higher than the calculated change rate, and combines the obtained forced termination upper limit power with a system output power target value up to the current time so as to generate a corrected system output power target value.

6. The solar power generation system according to claim 5,

wherein the power control device further includes a terminal provided with an insolation meter measuring an insolation amount and a display unit,

wherein the display unit of the terminal includes

a first display region that displays generated power output results of the solar power generation device and/or history of the insolation amount;

a second display region that displays a system diagram of the solar power generation system; and

a third display region that receives inputting of a parameter for defining the standard generated power.

7. A storage battery system comprising:

a storage battery that performs charging and discharging with solar generated power output from a solar power generation device; and

a power control device,

wherein the power control device includes

a variation component extraction unit that extracts a shade variation component from a generated power signal measured by the solar power generation device;

a smoothing unit that smoothens the shade variation component obtained by the variation component extraction unit;

a system output correction unit that obtains a system output power target value which is a combined output between a discharge output of the storage battery and the solar generated power on the basis of an output signal from the smoothing unit; and

a charge/discharge output correction unit that corrects a charge/discharge target value which is a difference between the system output power target value and the generated power signal on the basis of a current time and a state of charge of the storage battery.

8. The storage battery system according to claim 7,

wherein the power control device further includes a standard generated power calculation unit that obtains generated power obtained by the solar power generation device in fine weather as standard generated power, and

wherein the variation component extraction unit extracts the shade variation component on the basis of the generated power signal and the standard generated power.

9. The storage battery system according to claim 8,

wherein the charge/discharge output correction unit holds a threshold value of the state of charge in a preset nighttime period, and corrects the charge/discharge target value in a case where the current time is the set nighttime period and the state of charge of the storage battery exceeds the threshold value.

10. The storage battery system according to claim 9,

wherein the charge/discharge output correction unit holds information for defining different correspondence relationships between states of charge and deterioration tendencies depending on the type of storage battery, and sets a threshold value of the state of charge on the basis of the correspondence relationships between the states of charge and the deterioration tendencies.

11. The storage battery system according to claim 9,

wherein the system output correction unit calculates a change rate of a system output power target value at the current time on the basis of a current value and a system output power target value at a predetermined time before the current time among the system output power target values obtained in a predetermined cycle, obtains forced termination upper limit power having a change rate which is higher than the calculated change rate, and combines the obtained forced termination upper limit power with a system output power target value up to the current time so as to generate a corrected system output power target value.

12. A power control device comprising:

a variation component extraction unit that extracts a shade variation component from a generated power signal measured by a solar power generation device;

a smoothing unit that smoothens the shade variation component obtained by the variation component extraction unit;

a system output correction unit that obtains a system output power target value which is a combined output between a discharge output of a storage battery and the solar generated power on the basis of an output signal from the smoothing unit; and

a charge/discharge output correction unit that corrects a charge/discharge target value which is a difference between the system output power target value and the generated power signal on the basis of a current time and a state of charge of the storage battery.

13. The power control device according to claim 12, further comprising:

a standard generated power calculation unit that obtains generated power obtained by the solar power generation device in fine weather as standard generated power,

wherein the variation component extraction unit extracts the shade variation component on the basis of the generated power signal and the standard generated power.

14. The power control device according to claim **13**, wherein the charge/discharge output correction unit holds a threshold value of the state of charge in a preset nighttime period, and corrects the charge/discharge target value in a case where the current time is the set nighttime period and the state of charge of the storage battery exceeds the threshold value.

15. The power control device according to claim **13**, wherein the system output correction unit calculates a change rate of a system output power target value at the current time on the basis of a current value and a system output power target value at a predetermined time before the current time among the system output power target values obtained in a predetermined cycle, obtains forced termination upper limit power having a change rate which is higher than the calculated change rate, and combines the obtained forced termination upper limit power with a system output power target value up to the current time so as to generate a corrected system output power target value.

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